Length - weight relationships of freshwater fish from the Murray-Darling River System in inland New South Wales, with particular reference to the Golden Perch *Macquaria ambigua*

L. C. Llewellyn

Curlew Biological Services, PO Box 67, Pacific Palms, NSW 2428
Email: Leighton@activ8.net.au

ABSTRACT

Length - weight relationships for 29 fish species occurring in the Murray-Darling River System in inland NSW were determined using data collected principally between 1957 and 1970. In Golden Perch *Macquaria ambigua,* this relationship is examined with regard to locality, year and sex. In the Murrumbidgee River large females were more rotund than males. In the Murray River fish caught in November appeared to be more rotund than those caught in September supporting an increase in ovary size to be expected at this time of year, and 1960 fish were more rotund than fish from 1963 and 1964 also reflecting time of year and river heights. Twenty one of the species were examined with regard to all fish and sex differences. The remaining eight were examined for all fish combined only. In most cases a single curve adequately describes the relationship for each species, except when the population includes large numbers of maturing females or when substantial sexual dimorphism occurs, such as in *Philypnodon grandiceps* and *Mogurnda adspersa*. The relationships provided support for using shape to sex some species.

Key words: Length - weight relationships of Murray Darling fish, length - weight relationships of Golden perch *Macquaria ambigua*, sexual dimorphism.

Introduction

Length - weight relationships are determined for two main purposes (Le Cren 1951). Firstly, length - weight relationships describe the relationship between length and weight in a species so that one variable can be converted to the other. Secondly, any diversion from the mean relationship of the species or population can be assessed, which can indicate fatness, general well being, stomach fullness, stage of gonad development, sexual or racial differences (condition) etc. Wigley *et al.* (2003) and Kohler *et al.* (1996) are examples where length - weight relationships of many species have been described where conversion of weights to lengths or vice versa were needed for fisheries management purposes. The data presented here was initially collected for other research projects and thus falls partly into each of the above categories and is governed primarily by data availability. Obtaining large samples of inland fish on a regular basis is difficult, often impossible. Thus, this paper draws on data collected over 11 years in inland New South Wales. The amount of length weight data available for each species was very much dependent on, abundance of a species, size, catchability of species (Llewellyn 1968) and general interest in the species (angled, hobby collection or research interest). Golden Perch *Macquaria ambigua* tops the list and has thus facilitated further examination of this species.

Between 1959 and 1970 considerable numbers of the large inland freshwater species of fish in the Murray-Darling River System were sampled for research programs being carried out at the Inland Fisheries Research Station at Narrandera (currently known as the Narrandera Fisheries Centre). Most fish were collected during a tagging program which was initially a joint program between the New South Wales and Victorian Fisheries Departments, but was later continued by New South Wales (Llewellyn, 1968, 2008b). The data for the more detailed examination of Golden Perch *Macquaria ambigua*, was extracted from this program, whereas the data for other species was extracted from programs dealing with biological surveys and studies (Llewellyn 1966, 1971, 1973, 1974, 1979, 1980, 1983, 2005, 2006, 2007, 2008 a).

Pusey *et al.* (2004) has summarised some length weight relationships of species occurring in north east Australia and has thus covered 10 of the 27 species that also occur in the Murray – Darling River System. In 16 of the 27 species virtually no data is available at least for populations occurring in the Murray-Darling River System. Some of the previous data reported is presented in the results and discussion for each individual species.

Methods

Large fish were normally captured using drum or fyke nets (11.0cm diagonal mesh or greater), during spring river-floods when catches in inland freshwaters were highest (Llewellyn 1968). Thus, most large fish were caught between September and December and were > 30cm and > 500g. Gill nets (10cm diagonal mesh or greater) were used occasionally in lakes and backwaters of rivers where flows were minimal. For smaller fish species a haul net (seine), dip nets, bait traps, a beam push net, electro-fishing gear and fish poisons such as rotenone were used. The total length, weight, sex (where it could be determined), date, locality, scale samples, species and tag number, where applicable, were recorded or taken. Only total lengths have been used in this paper. The sex was determined by shape of fish or urinogenital papilla, colour and size of the vent

and by extruding milt or ova, and was confirmed in many cases during the tagging process, which involved making an incision in the abdominal wall to insert the tag. In many cases the gonads could be seen through the incision.

Length - weight analyses were determined for those species in which sufficient data was available, and the splitting of data into subgroups i.e. female, male, unknown (all data combined includes unknown sex), was also influenced by the quantity of data. The numbers of fish used in this study are shown in Table 1. With the exception of *M. ambigua*, the data from different sampling localities were pooled. Details of sampling sites for each species are given in the Results and Discussion. For ease of locating, species have been listed in alphabetical order of scientific name.

Data for *M. ambigua* has been split both spatially, by location, and by time into further subgroups. The localities at which *M. ambigua* were collected are Narrandera (34°46'S, 146°33'E) and Hay, "Pevensey" (34°34'S 144° 38'E) both on the Murrumbidgee River, and Hattah near the upstream junction of Chalka Creek with the Murray River (34°44'S 142°30'E) and Ned's Corner, Stony Crossing (34°08'S 141°30'E) both on the Murray River.

The length - weight relationship is adequately described by the formula:-

$$y = Ax^B$$

where "y" = weight, "x" = length, "A" is a constant and "B" is an exponent usually lying between 2.5 and 4 (B = 3 for isometric growth where the rate of growth of length, breadth and depth of a fish is equal) (Everhart *et al.*1976, Le Cren 1951)). This value is seldom 3 thus indicating that allometric growth is usually occurring (Everhart *et al.*1976). Scientific notation has been used in formulas e.g. (1.47E-06 $1.47x10^{-6}$). The trend lines of the graphs give a visual picture as to how close the relationships are. However the significance of these relationships were determined using a "comparison of two slopes" as indicated by Zar (1984 p.292) following a $\log_{10} \log_{10}$ transformation of the data sets.

Table 1. Number of specimens used in length - weight relationships of freshwater fish that occur in the Murray Darling River System in inland New South Wales. * Species which occur in the inland but some material was used from the eastern flowing rivers.

Scientific Name	Common Name	Numbers used			
		Total	Males	Females	Unknown
Ambassis agassizii	Agassiz's Glassfish	171	59	51	61
*Anguilla australis**	Short-finned Eel	215	0	0	215
Bidyanus bidyanus	Silver Perch	1335	811	181	343
Carassius auratus	Goldfish	34	1	17	16
Craterocephalus fluviatilis	Murray Hardyhead	39	12	19	8
Cyprinus carpio	Common Carp	82	0	0	82
Gadopsis marmoratus	River Blackfish	105	30	22	53
*Galaxias olidus**	Mountain Galaxias	23	0	0	23
Galaxias rostratus	Murray Jollytail	33	8	21	4
*Gambusia holbrooki**	Mosquitofish	162	17	22	123
Hypseleotris sp.	Carp Gudgeon	133	23	39	71
Leiopotherapon unicolor	Spangled Perch	142	22	19	101
Maccullochella macquariensis	Trout Cod	6	0	0	6
Maccullochella peelii	Murray Cod	357	47	107	203
Macquaria ambigua	Golden Perch	2378	835	272	1271
Macquaria australasica	Macquarie Perch	27	10	4	13
Melanotaenia fluviatilis	Murray River Rainbowfish	16	15	1	0
Mogurnda adspersa	Purple-spotted Gudgeon	70	27	28	15
Nannoperca australis	Southern Pygmy Perch	149	26	24	99
Nematalosa erebi	Bony Bream	126	5	9	112
*Oncorhynchus mykiss**	Rainbow Trout	366	185	102	79
*Perca fluviatilis**	English Perch	726	255	400	71
*Philypnodon grandiceps**	Flat-headed Gudgeon	19	5	14	0
Retropinna semoni	Australian Smelt	13	0	0	13
*Salmo salar**	Atlantic Salmon	47	7	7	33
*Salmo trutta**	Brown trout	542	287	232	23
*Salvelinus fontinalis**	Brook Char	88	18	25	45
Tandanus tandanus	Freshwater Catfish	284	49	81	154
Tinca tinca	Tench	103	25	49	29

Results and Discussion

Some factors affecting length weight relationships of Golden Perch *Macquaria ambigua*

The length - weight relationship curves for golden perch (Figs 1a-c; 2; 3a, b; 4; 5) (mathematical

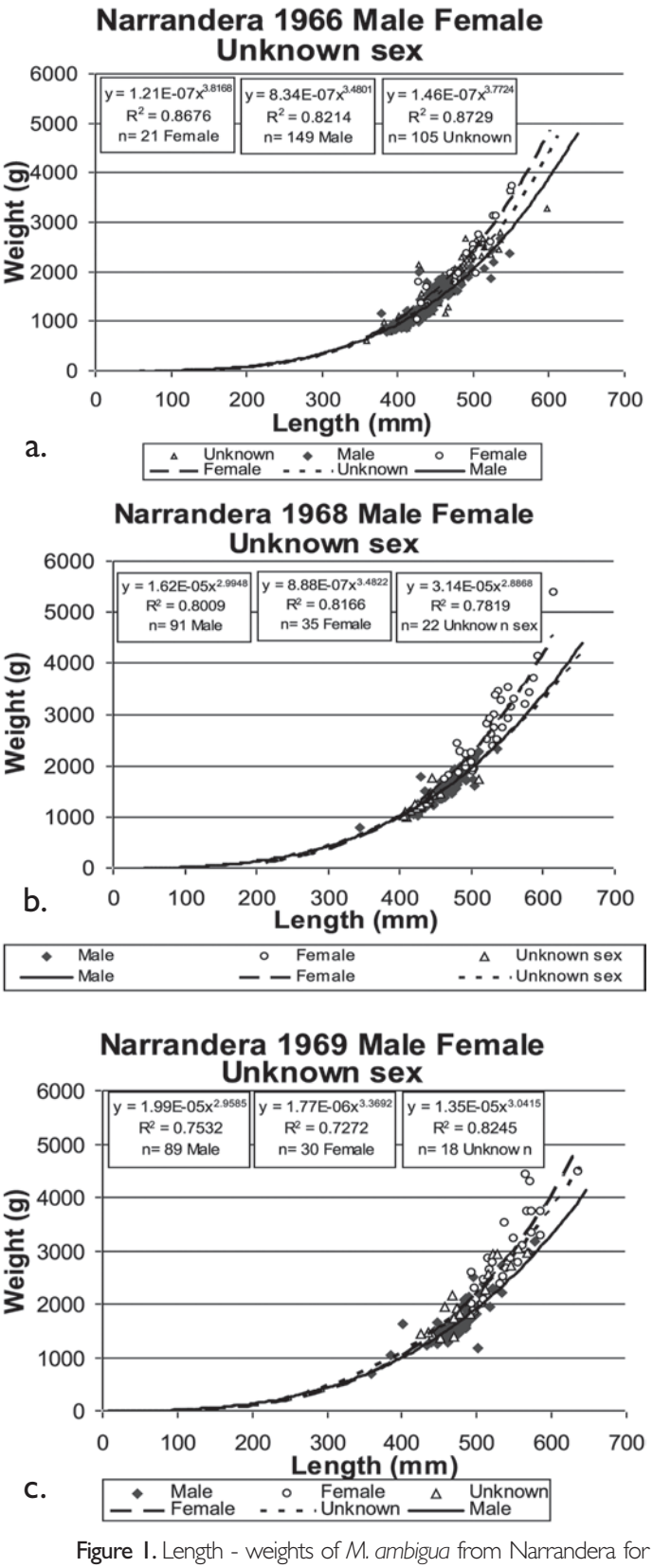


Figure 1. Length - weights of *M. ambigua* from Narrandera for males, females and unknown sex in a 1966, b 1968 and c 1969.

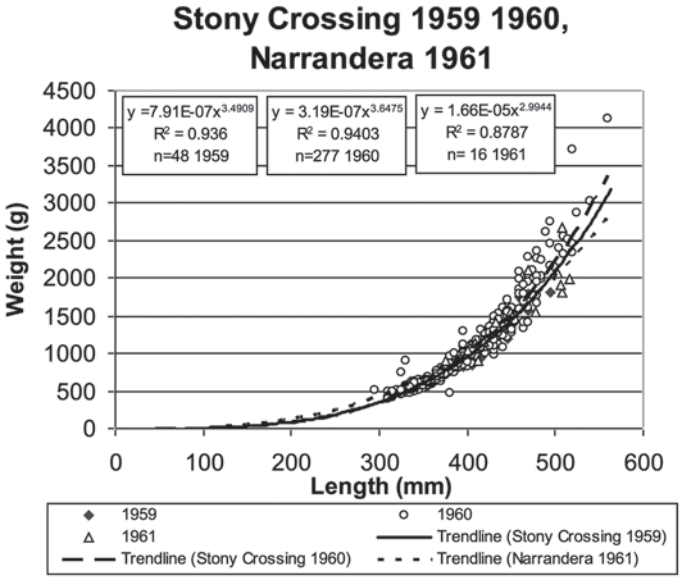


Figure 2. Length - weights of *M. ambigua* from Stony Crossing in 1959 and 1960, and Narrandera in 1961.

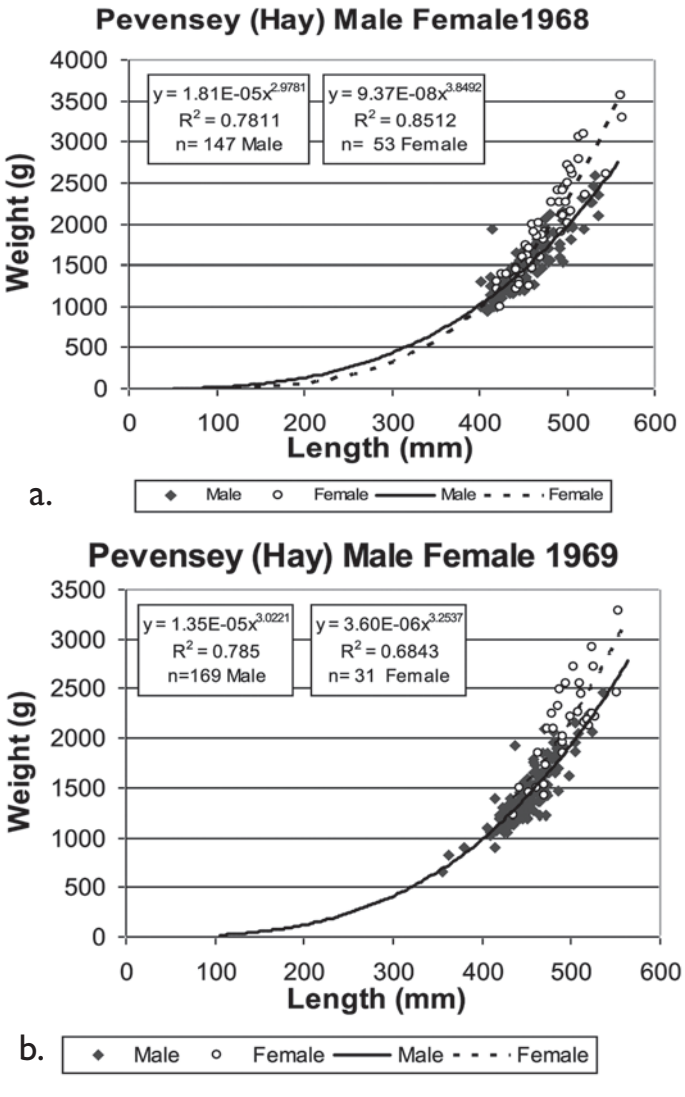


Figure 3. Length - weights of *M. ambigua* from Pevensey (Hay) for males and females in a 1968 and b 1969.

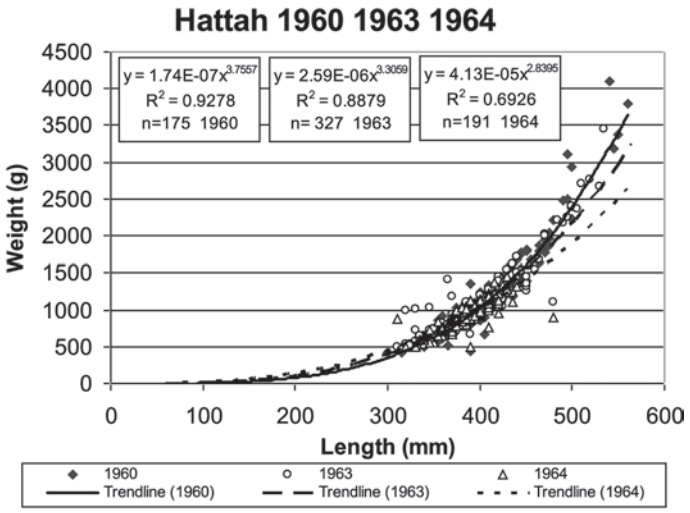


Figure 4. Length - weight of *M. ambigua* from Hattah in 1960, 1963 and 1964.

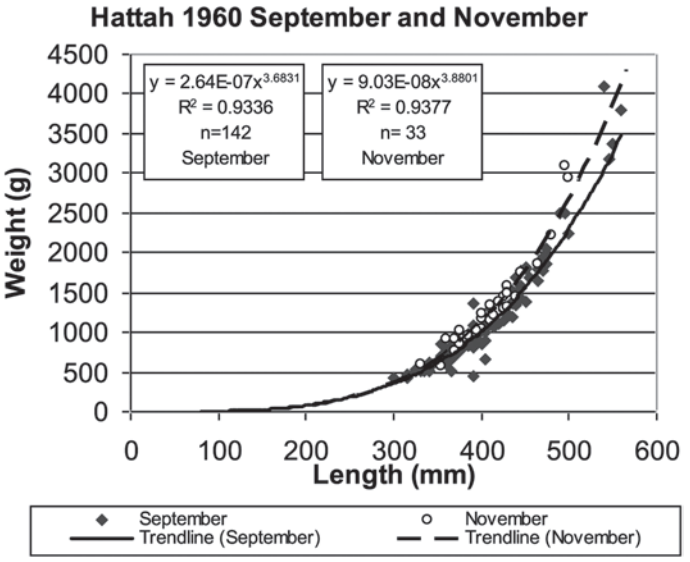


Figure 5. Length - weight of *M. ambigua* from Hattah in September and November 1960.

derivatives Table 2) all have similar shapes; however plots indicate differences particularly in large fish with respect to sex and time, and some of these differences were significant. The slope of curves for males and females from Hay in 1968 and for all male (835) and female (272) M *ambigua* were significantly different. Similar sized drum nets used at Narrandera and Hay (Pevensey) districts during springtime captured fish above 344 mm in length and 750 g in weight. The means of grouped fish from these two areas ranged in length from 437 mm in unknown sex to 541 mm in females both from Narrandera and in weight from 1329 g in unknown sex to 2928 g in females also both from Narrandera (Table 2). A comparison of these curves is therefore justified. The exact mesh size of drum nets used at Stony Crossing and Hattah is not known, but the mean size of grouped fish is smaller varying from 381 to 416 mm in length and 925 to 1303 g in weight.

The numbers of females that could be accurately sexed were always smaller than male numbers (Table 1), 1:3.07 females to males. Large females at a given length weighed more than males (Figs 1 and 3). The rotundness of females caused by rapidly growing gonads is one of the characters which assist in sexing this fish, along with the size and colour of the vent. Males could only be identified by extruding milt or when an incision was made. Unknown sex plots include a mixture of males and females (Fig. 1a and c) and they generally fall between those of males and females. However in Fig. 1b the plot for unknown sex is very similar to that for males, suggesting most of these fish are males or possibly non breeding females.

Quiescent females are very similar in shape to males. The uniformity of shape in males is shown in curves for males in the Hay sample (see exponents Fig, 3 a, b) in 1968 and 1969, while the females show marked differences probably a result of reproductive state. The difference in females in the Hay samples is likely to be associated with the fact that river levels at Balranald reached 2.6m for a brief period in spring1968, while in 1969 a prolonged flood of up to 4.7m occurred (Llewellyn 1978 a and b). High rivers or floods are known to stimulate gonad development and the onset of spawning (Lake 1967). Isometric growth (B = 3) in Table 2, is more closely approached in males than in females, when comparing samples from the same area or year.

Length – weight relationships in fish captured at Hattah in 1960, 63 and 64 varied (Fig, 4). The 1964 sample was taken in August late winter when gonad development is likely to be limited giving rise to a low weight per length and was significantly different from the 1960 data. The 1960 and 1963 samples were taken in September/November and October respectively, but fish condition was poorer in 1963 when river levels were much lower. Splitting the Hattah 1960 sample into fish caught in September and November (Fig. 5) indicates that the weight of fish increased in relation to length over this period, although the difference was not significant. It is suggested that the variation in these curves is caused, primarily by gonad development of females when conditions are suitable as the breeding season approaches, but could also be influenced by an increase in food supply at this time of year.

The seasonal differences at Stony Crossing (Neds Corner) December 1959 and September 1960 on the Murray (Fig. 2) appear to be similar to those occurring in widely separated areas such as, Narrandera 1961 on the Murrumbidgee River . The Narrandera 1961 and Stony Crossing 1960 are significantly different.

The mean size of fish in the samples taken at Narrandera between 1966 and 1969 showed a gradual increase over this period (Table 2) even though sampling methods were the same. This is probably due to the drought period prior to 1969 interfering with recruitment and the advancement of size classes into the smaller size ranges taken by the nets used.

Table 2. Length weight relationships of *Macquaria ambigua* from different localities, sexes and times. n= number of fish, x = length in (mm), y=weight in (g), A is a constant and B is the exponent. r^2 is coefficient of determination of the regression, P is significance of the difference of the slopes between the two relevant equations and Standard Deviation indicates the variance in the data sets.

Locality	Year	Sex	n	Range	Means		Standard Deviation		$y= Ax^B$		r^2	P
				mm	$\bar{x}$	$\bar{y}$	x	y	A	B		
Narandera	1966	Female	21	426-551	485.95	2249.10	38.43	719.74	1.21E-07	3.8168	0.8676	NS
Narrandera	1966	Male	149	379-548	438.59	1339.10	30.18	360.51	8.34E-07	3.4801	0.8214	
Narrandera	1966	Unknown	105	359-597	458.48	1671.57	40.16	585.61	1.46E-07	3.7724	0.8729	
Narrandera	1968	Female	35	463-614	528.17	2760.89	35.94	764.21	8.88E-07	3.4822	0.8166	NS
Narrandera	1968	Male	91	344-536	462.86	1578.25	27.21	307.35	1.62E-05	2.9948	0.8009	
Narrandera	1968	Unknown	22	405-510	436.91	1329.23	24.48	256.34	3.14E-05	2.8868	0.7819	
Narrandera	1969	Female	30	493-635	541.20	2928.08	34.29	734.03	1.77E-06	3.3692	0.7272	NS
Narrandera	1969	Male	89	359-578	476.33	1702.91	32.20	412.50	1.99E-05	2.9585	0.7532	
Narrandera	1969	Unknown	18	425-567	489.71	2103.41	42.66	606.19	1.35E-05	3.0415	0.8245	
Hay	1968	Female	53	421-563	476.26	1966.85	33.91	586.70	9.37E-08	3.8492	0.8512	P<0.001
Hay	1968	Male	147	402-535	454.48	1514.12	30.76	354.49	1.81E-05	2.9781	0.7811	
Hay	1969	Female	31	436-553	494.42	2139.05	29.14	475.45	3.60E-06	3.2537	0.6843	NS
Hay	1969	Male	169	356-535	452.33	1449.29	26.21	290.79	1.35E-05	3.0221	0.7850	
Narrandera	1961	Unknown	16	376-516	447.67	1503.44	50.23	539.80	1.66E-05	2.9944	0.8787	P<0.02
Stony Crossing	1960	Unknown	277	330-495	402.71	1109.3	52.41	593.05	3.19E-07	3.6475	0.9403	
Stony Crossing	1959	Unknown	48	295-560	416.25	1137.35	35.51	332.68	7.91E-07	3.4909	0.9360	
Hattah	1960	Unknown	175	300-560	397.97	1104.81	47.38	608.82	1.74E-07	3.7557	0.9278	P<0.001
Hattah	1964	Unknown	191	310-535	387.67	938.06	23.22	185.38	4.13E-05	2.8395	0.6926	
Hattah	1963	Unknown	327	310-480	381.02	925.07	37.99	393.73	2.59E-06	3.3059	0.8879	
Hattah	1960 Sept.	Unknown	142	300-560	395.35	1058.67	48.84	611.25	2.64E-07	3.6831	0.9336	NS
Hattah	1960 Nov	Unknown	33	330-500	409.24	1303.33	39.15	564.88	9.03E-08	3.8801	0.9377	

Length (x) - weight (y) relationships of freshwater fish from the Murray- Darling River System (in alphabetical order of scientific name)

A comparison between the sexes is made wherever adequate data is available. When comparing the significance of differences of length weight relationships of males and females, it can be influenced by the range of sizes in the sample, particularly the numbers of sexually mature (large) fecund females present in the sample. In a few cases significance was different to what was expected because of this bias in the sample.

Agassiz's Glassfish *Ambassis agassizii*

All $y=1.07E\text{-}05x^{3.0086}$. Male $y=1.12E\text{-}05x^{2.9964}$.
Female $y=4.40E\text{-}06x^{3.2299}$.

Most of the sample (135) was collected at Barren Box Swamp while other specimens were collected from the MacIntyre, Narran and Bokhara Rivers and Lake Brewster. They ranged from 15.5 to 68.0 mm in length and 0.03 to 3.89 g in weight. The mean weight and length of males and females in the sample was 1.31 g and 47.7 mm, and 1.68 g and 51.8 mm respectively (Table 3). The curves were marginally steeper for females, although the difference was not significant (Fig. 6). Pusey *et al.* (2004)

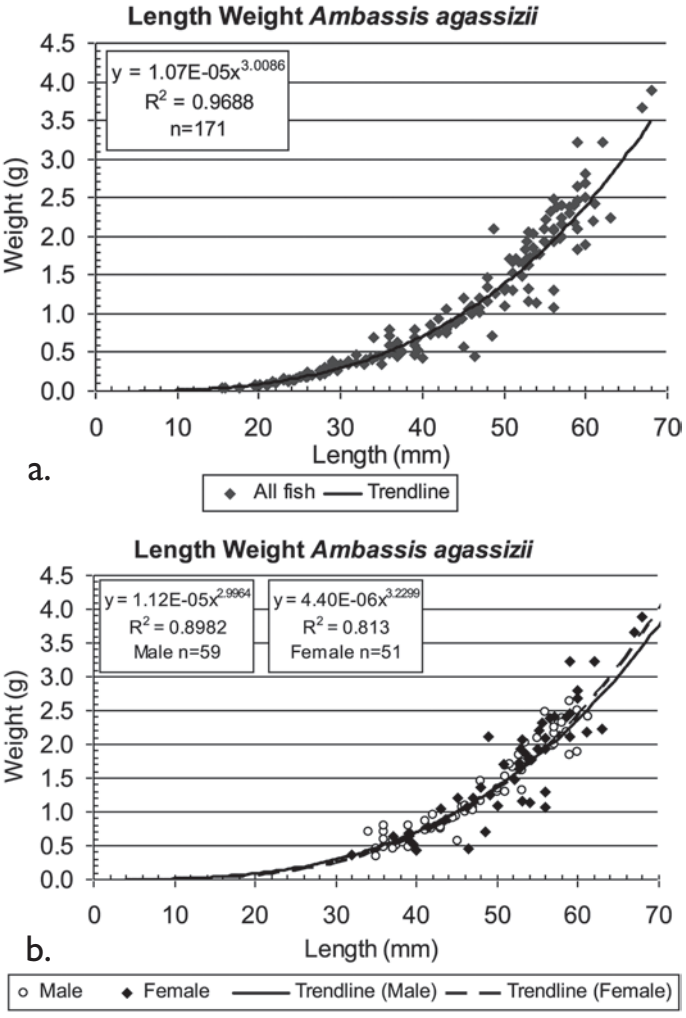


Figure 6 Length - weight relationship for *Ambassis agassizii* (Agassiz's Glassfish). a, all fish grouped. b, males and females.

Table 3. Length weight relationships of freshwater fish from inland NSW. Where available, parameters for all, male (M) and female (F) fish are given. n= number of fish, x=length in mm, y=weight in g, A=constant, B= exponent, r^2 is coefficient of determination of the regression, and P is significance of the difference of the slopes between the male and female regressions. Standard Dev. indicates the variance in the data sets

Species	Sex	n	Length Range (mm)	Means		Standard Dev.		$y=Ax^B$		r^2	P
				$\bar{x}$	$\bar{y}$	x	y	A	B		
Ambassis agassizii	All	171	15.5-68	41.2485	1.0351	13.2735	0.8668	1.07E-05	3.0086	0.9688	NS
	M	59	34-61.2	47.6509	1.3081	8.0418	0.6603	1.12E-05	2.9964	0.8982	
	F	51	32-68	51.7824	1.6840	7.9448	0.8492	4.40E-06	3.2299	0.8130	
Anguilla australis	All	215	228-982	673.3163	641.9933	141.0053	386.1345	1.49E-07	3.3812	0.9631	P<0.05
	M	-	-	-	-	-	-	-	-	-	
	F	-	-	-	-	-	-	-	-	-	
Bidyanus bidyanus	All	1335	150-596	430.4966	1228.909	39.0939	378.9159	5.58E-06	3.1616	0.8737	
	M	811	347-531	426.6375	1156.803	30.5956	294.6567	9.09E-06	3.0779	0.7987	
	F	181	377-596	445.0829	1425.895	35.0737	454.5636	2.15E-06	3.3257	0.7839	
Carassius auratus	All	34	138-650	324.8824	902.9706	103.6248	585.9515	0.000109	2.7216	0.8578	
	M	1	-	-	-	-	-	-	-	-	
	F	17	-	332.7647	920.7059	53.0984	410.6855	-	-	-	

Species	Sex	n	Length Range (mm)	Means		Standard Dev.		$y=Ax^B$		r^2	P
				$\bar{x}$	$\bar{y}$	x	y	A	B		
Craterocephalus fluviatilis	All	39	33-78.5	53.8923	1.4238	10.3283	0.7907	1.47E-05	2.8541	0.9135	NS
	M	12	42-75	53.8333	1.3306	8.9336	0.7197	1.27E-05	2.8802	0.9053	
	F	19	47.1-78.5	59.0421	1.8114	7.9820	0.7352	1.71E-05	2.8231	0.7777	
Cyprinus carpio	All	82	208-860	422.9634	1415.502	132.1511	1489.903	8.86E-06	3.0741	0.9571	
	M	-	-	-	-	-	-	-	-	-	
	F	-	-	-	-	-	-	-	-	-	
Gadopsis marmoratus	All	105	130-325	232.6857	93.5133	50.7575	56.0470	1.39E-05	2.8621	0.9704	NS
	M	30	130-310	217.8000	74.7400	45.4710	45.0282	1.54E-05	2.8394	0.9574	
	F	22	152-325	234.8636	104.6909	57.3006	68.3308	1.14E-05	2.9098	0.9798	
Galaxias olidus	All	23	44-76.5	53.9174	0.9087	8.4696	0.4529	1.02E-05	2.8409	0.8790	
	M	-	-	-	-	-	-	-	-	-	
	F	-	-	-	-	-	-	-	-	-	
Galaxias rostratus	All	33	52.5-150	83.9879	5.2645	27.3570	6.0660	4.20E-07	3.5916	0.9857	NS
	M	8	61.7-111.5	88.8750	5.3825	19.0794	3.5641	3.83E-07	3.6268	0.9703	
	F	21	52.5-150	86.5619	6.0300	30.7163	7.0840	5.12E-07	3.5438	0.9877	
Gambusia holbrooki	All	162	11.5-58	21.8734	0.2253	9.7439	0.4182	6.65E-06	3.1684	0.9762	NS
	M	17	15-31.5	26.5882	0.2335	4.7803	0.1102	7.65E-06	3.1180	0.9814	
	F	22	27-58	42.6818	1.1105	7.4235	0.5921	4.11E-06	3.3038	0.9777	
Hypseleotris sp.	All	133	14.5-49	31.2857	0.3742	6.8225	0.2794	3.51.E-06	3.3106	0.9678	NS
	M	23	28-49	39.5870	0.7548	5.9709	0.3491	1.01.E-05	3.0307	0.9368	
	F	39	25-44	34.3974	0.4541	4.1647	0.1796	6.61.E-06	3.1333	0.9420	
Leiopotherapon unicolor	All	142	30-252	76.5827	16.2271	43.4922	34.6847	2.62E-06	3.3838	0.9889	P<0.005
	M	22	76.5-149	103.6818	18.8034	17.3470	11.9664	5.45E-06	3.2200	0.9310	
	F	19	5.9-164	118.5000	33.4789	27.2646	21.8861	5.66E-06	3.2321	0.9736	
Maccullochella macquariensis	All	6	280-610	406.0000	1337.000	138.1593	1263.210	7.15E-05	2.7492	0.9819	
	M	-	-	-	-	-	-	-	-	-	
	F	-	-	-	-	-	-	-	-	-	
Maccullochella peelii peelii	All	357	88-1295	617.5978	6176.386	238.9819	6215.192	2.75E-06	3.2848	0.9893	NS
	M	47	394-1092	722.8411	8374.704	182.1473	6724.924	1.96E-06	3.3344	0.9726	
	F	107	307-1295	730.5819	8380.375	165.5532	5906.451	8.67E-06	3.1129	0.9545	

Species	Sex	n	Length Range (mm)	Means		Standard Dev.		$y=Ax^B$		r^2	P
				$\bar{x}$	$\bar{y}$	x	y	A	B		
Macquaria ambigua	All	2378	9.5-635	332.0686	893.9597	139.7561	869.6347	7.08E-06	3.1246	0.9788	P<0.001
	M	835	207-578	423.0689	1278.677	74.6392	567.7540	1.33E-06	3.4020	0.9750	
	F	272	217-635	456.3522	1901.887	95.1168	1064.924	5.29E-07	3.5652	0.9746	
Macquaria australasica	All	27	178-508	323.1852	579.8889	66.5398	320.0653	0.000472	2.4110	0.8531	
	M	-	-	-	-	-	-	-	-	-	
	F	-	-	-	-	-	-	-	-	-	
Melanotaenia fluviatilis	All	16	46-88	66.6875	2.9436	13.2248	1.7184	1.26E-05	2.9180	0.9564	
	M	-	-	-	-	-	-	-	-	-	
	F	-	-	-	-	-	-	-	-	-	
Mogurnda adspersa	All	70	31.1-94	55.0712	2.0105	11.9255	1.4740	3.50E-06	3.2632	0.9876	P<0.005
	M	27	44.7-67.2	57.3740	2.0941	5.9811	0.6750	2.51E-06	3.3565	0.9767	
	F	28	49-94	62.3714	2.7472	9.1194	1.7986	8.66E-06	3.0449	0.9391	
Nannoperca australis	All	149	23.1-63	34.1309	0.7023	10.3722	0.7689	8.26E-06	3.1273	0.9841	P<0.05
	M	26	36-56	45.0769	1.2878	6.0970	0.5691	4.98E-06	3.2549	0.9612	
	F	24	31-63	48.5625	1.8383	9.2081	0.9445	2.75E-05	2.8366	0.9497	
Nematalosa erebi	All	126	218-444	327.5921	392.3095	39.6895	175.5366	1.45E-06	3.3403	0.8978	NS
	M	5	243-302	274.6040	243.5650	22.4565	69.7950	3.97E-07	3.5975	0.6961	
	F	9	218-371	286.5089	289.4690	47.4534	122.7700	1.97E-05	2.9044	0.8094	
Oncorhynchus mykiss	All	366	72-547	201.0764	190.6759	116.7545	319.7870	2.39E-05	2.8557	0.9871	NS
	M	185	77-547	196.8270	152.6180	99.9553	239.9515	2.92E-05	2.8192	0.9833	
	F	102	84-516	238.6176	267.6181	132.9281	329.7197	2.51E-05	2.8428	0.9945	
Perca fluviatilis	All	726	50.8-492	249.1537	363.6722	94.2003	464.0532	2.47E-06	3.3127	0.9594	P<0.05
	M	255	112-470	230.8824	252.5961	79.4273	378.9708	1.96E-06	3.3421	0.9860	
	F	400	111-492	258.8025	422.0525	102.4070	515.9275	1.42E-06	3.4117	0.9894	
Philypnodon grandiceps	All	19	44-110	75.9474	4.6301	19.2973	3.5219	3.85E-06	3.1858	0.9872	NS
	M	5	68-79	74.8000	3.5708	4.3243	1.0898	4.00E-09	4.7690	0.8499	
	F	14	44-110	76.3571	5.0084	22.5648	4.0278	4.14E-06	3.1719	0.9946	
Retropinna semoni	All	13	32-88	58.4231	1.5085	14.9887	1.1439	4.12E-06	3.1062	0.9833	
	M	-	-	-	-	-	-	-	-	-	
	F	-	-	-	-	-	-	-	-	-	

Species	Sex	n	Length Range (mm)	Means		Standard Dev.		y=Ax^B		r²	P
				x̄	ȳ	x	y	A	B		
Salmo salar	All	47	107-565	281.2766	300.5957.	131.5416	426.4414	2.76E-05	2.7739	0.9238	
	M	7	190-545	357.0000	497.7143	144.8666	465.6826	1.53E-05	2.8904	0.9908	NS
	F	7	223-565	472.7143	934.5714	125.0623	518.0842	8.66E-06	2.9765	0.9531	
Salmo trutta	All	542	19-673	225.5775	281.7817	141.2980	488.8346	3.24E05	2.7928	0.9711	
	M	287	100-673	228.8362	296.8548	143.5065	517.7123	1.94E05	2.8905	0.9902	NS
	F	232	100-584	225.9440	277.0855	140.3578	466.3970	2.10E05	2.8714	0.9874	
Salvelinus fontinalis	All	88	55-394	146.1705	64.5682	74.2645	100.1142	1.35E-05	2.9548	0.9773	
	M	18	86-273	137.1110	48.2222	62.9359	66.1607	1.57E-05	2.9289	0.9842	NS
	F	25	87-295	200.2000	121.0800	65.2348	93.3983	1.30E-05	2.9761	0.9869	
Tandanus tandanus	All	284	44-610	335.5405	627.6630	137.3617	612.1130	5.88E-06	3.1007	0.9808	
	M	49	224-599	383.9388	764.9796	100.7392	675.2991	2.42E-06	3.2465	0.9577	NS
	F	81	242-584	421.5556	975.3704	90.8343	636.9459	1.43E-06	3.3369	0.9738	
Tinca tinca	All	103	210-528	446.2565	1492.214	60.4632	445.5801	9.82E-06	3.0797	0.9542	
	M	25	298-493	443.8548	1414.040	40.9926	304.3243	1.98E-06	3.3395	0.9885	NS
	F	49	210-528	458.6698	1606.429	70.4307	524.2499	3.96E-06	3.2229	0.9652	

records the length weight relationship for fish in the Mary River in Queensland as

$W=2.0x10^{-5}SL^{3.119}$, $r^2=0.956$, n=927, in which the exponent is slightly higher than the value of 3.0086 for all fish in this study.

Short-finned Eel *Anguilla australis*

All $y=1.49E\text{-}07x^{3.3812}$

A. australis occur only occasionally in the Murray - Darling River System, having navigated through the Snowy Scheme from the eastern to western watersheds. The specimens used here were from eastern flowing streams. Within the sample, 213 were collected from Wollondibby Creek 5 km west of Jindabyne NSW (36°24.8'S, 148°34.4'E) and 2 from Saucy Creek 16 km E of Delegate NSW. They ranged from 228 to 982 mm in length and 28 to 1720 g in weight. The mean weight and length of all fish in the sample was 642 g and 673 mm (Table 3). No gonads were evident macroscopically on dissection so sex was not determined. The length weight relationship plot (Fig. 7) indicated the exponent value was 3.3812 and that growth was strongly allometric. Sloane (1984) described a length weight relationship for this species as Log W=3.4Log L-3.477, $r^2=0.984$. $p<0.001$, n=80. Pease *et al* (2004) found that in *Anguilla reinhardtii* in NSW the slopes of length weight plots for males, females, and fish from different rivers were not significantly different but fish from freshwater and tidal waters were. The length weight relationship for undifferentiated fish was $\log_{10}$ weight=$\log_{10}$ -5.39 + 2.94 $\log_{10}$ length, (r^2 = 0.81).

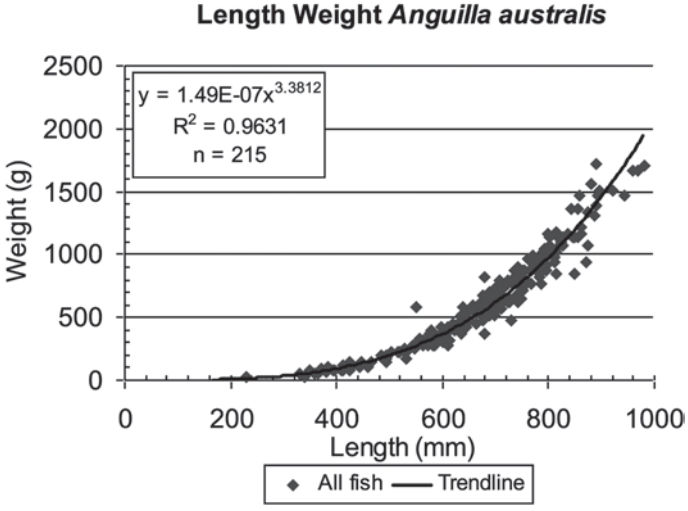


Figure 7. Length - weight relationship for *Anguilla australis* (Short-finned Eel). The data available is for all fish, unknown sex only.

Silver Perch *Bidyanus bidyanus*

All $y=5.58E\text{-}06x^{3.1616}$. Male $y=9.09E\text{-}06x^{3.0779}$. Female $y=2.15E\text{-}06x^{3.3257}$.

In *B. bidyanus* 1257 of the 1335 (or 94.2%) were caught in the Narrandera area, 56 were in the Hay area, 9 at Balranald all in the Murumbidgee River, and 13 elsewhere. Fish were caught mainly by drum nets. Length - weight relationships for males and females were significantly different, however the slopes of the plots for males, and all data combined (Fig, 8, and Table 3) were very similar. The mean lengths

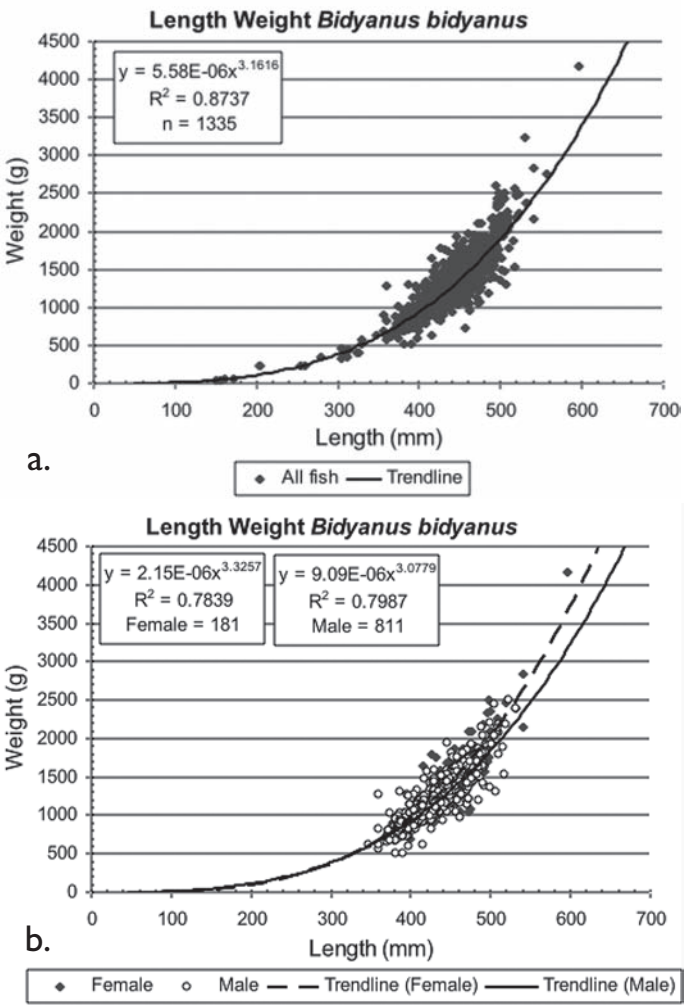


Figure 8. Length - weight relationship for *Bidyanus bidyanus* (Silver Perch). a, all fish grouped. b, males and females.

of males and females were 427 and 445 mm and mean weights were 1157 and 1426 g respectively. The females were larger than males at any given weight (Fig. 8), which is influenced by gonad development and body weight, but the difference is not as large as that found in *M. ambigua*. The sexes of live *B. bidyanus* are not easily separated on shape. The value of the exponent in the length - weight equation varies from 3.0779 in males to 3.3257 in females suggesting it is a rotund fish with at least the females having allometric growth. The ratio of males to females in the sample was 4.5:1 showing a high preponderance of males, similar to the ratio in the sample of *M. macquaria*.

Goldfish *Carassius auratus*

All $y=0.000109x^{2.7216}$

C. auratus were all collected within 150km of Narrandera by gill netting and seine netting. They ranged from 138 to 650 mm in length and 41 to 2835 g in weight. The mean weight and length of fish in the sample was 903 g and 325 mm respectively (Table 3). There were insufficient males in the sample to compare sex differences in the length - weight relationship curves (Fig.9, Table 3). In practice it is generally not possible to differentiate between the sexes on the basis of the shape in this species. The low exponent (2.7216) in the length - weight relationship equation indicates an allometric growth pattern.

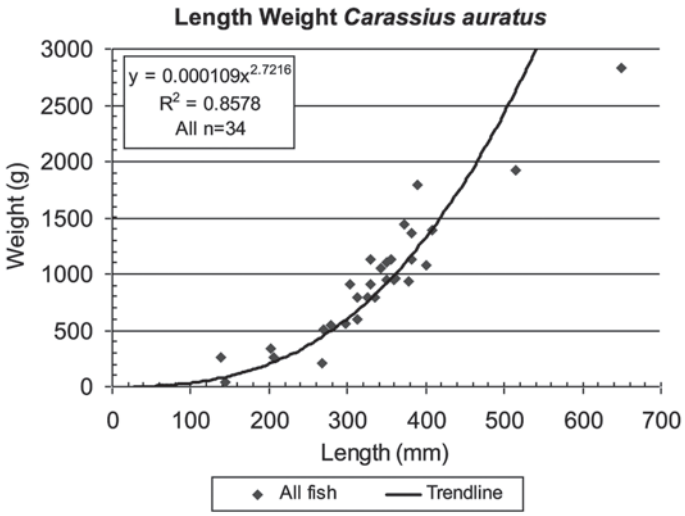


Figure 9. Length - weight relationship for *Carassius auratus* (Goldfish). The data available is for all fish, unknown sex only.

Murray Hardyhead *Craterocephalus fluviatilis*

All $y=1.47E\text{-}05x^{2.8541}$. Male $y=1.27E\text{-}05x^{2.8802}$.
Female $y=1.71E\text{-}05x^{2.8231}$.

In the *C. fluviatilis* samples 30 were taken at Barren Box Swamp between 1968 and 1971 and many of these had been kept in ponds at the Narrandera Fisheries Centre for some time, 5 were from Euston on the Murray and

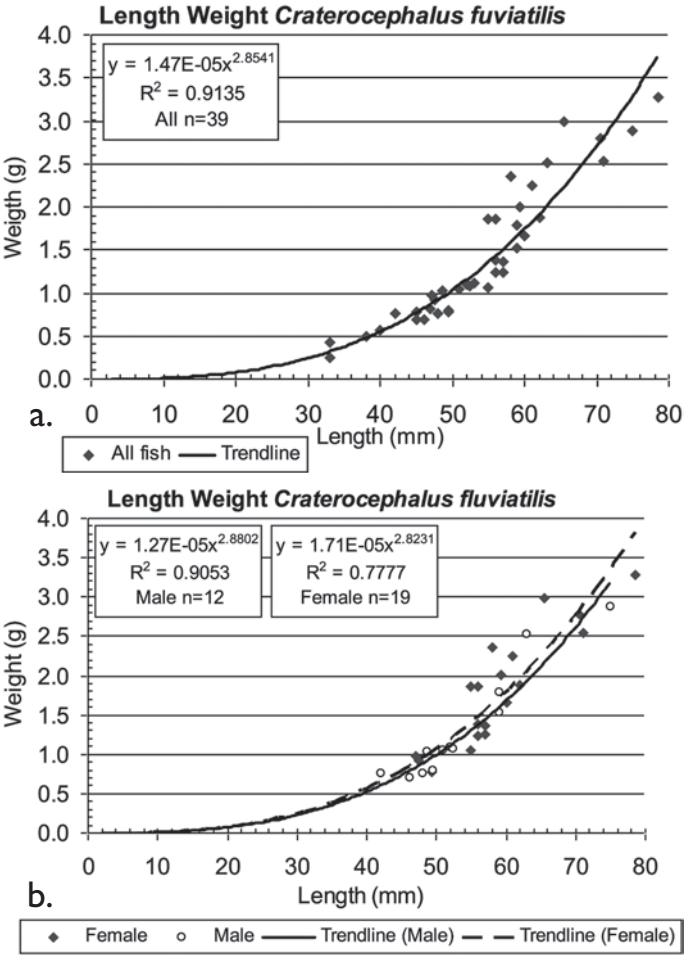


Figure 10. Length - weight relationship for *Craterocephalus fluviatilis* (Murray Hardyhead). a, all fish grouped. b, males and females.

the rest were unknown localities. They ranged from 33.0 to 78.5 mm in length and 0.26 to 3.28 g in weight. The mean weight and length of males and females in the sample was 1.33 g and 53.8 mm, and 1.81 g and 59.0 mm respectively (Table 3). The curves for males and females were not significantly different (Fig. 10), but large females had a slightly larger weight per length resulting probably from gravid females.

Common Carp *Cyprinus carpio*

All $y=8.86E\text{-}06x^{3.0741}$

C. carpio were collected from Moomin Creek (29°41'S, 149°30'E) in Nov 1971 (61), the orange variety (*C. carpio* Yanco (Shearer and Mulley 1978)) from the Yanco irrigation Canal near Narrandera in March 1969 (16) and the rest elsewhere, all by gill netting. They ranged from 208 to 860 mm in length and 140 to 7371 g in weight. Their mean weight and length was 1416 g and 423 mm respectively (Table 3). The sex of these fish could not be determined from external appearance. The exponent (3.0741) of the length - weight relationship (Fig. 11 and Table 3) was close to 3, that for isometric growth.

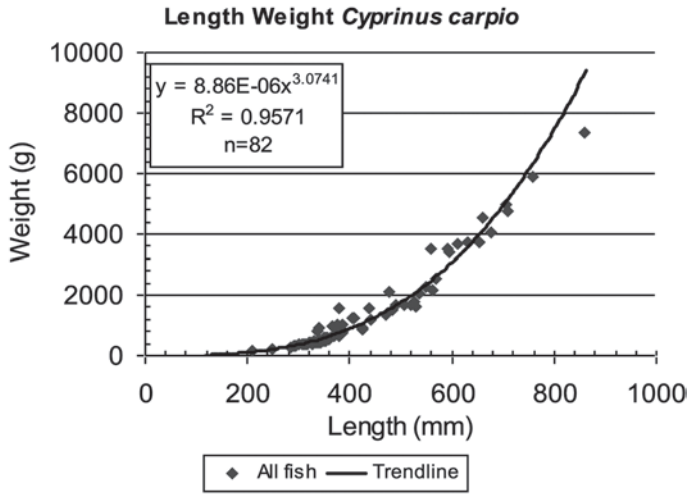


Figure 11. Length - weight relationship for *Cyprinus carpio* (Common Carp). The data available is for all fish, unknown sex only.

River Blackfish *Gadopsis marmoratus*

All $y=1.39E\text{-}05x^{2.8621}$. Male $y=1.54E\text{-}05x^{2.8394}$. Female $y=1.14E\text{-}05x^{2.9098}$

In *G. marmoratus* 89 of the sample were obtained from Billabong Creek near Walbundrie (35°41'S 146°43'E) and 16 from the Yanco Irrigation Canal west of Narrandera. Fish were caught throughout the year by angling and they ranged in length and weight from 130 to 325 mm and 13.2 to 267.0 g respectively. The mean lengths and weights of males and females (Table 3) ranged from 217.8mm to 74.74 g and 234.9 mm to 104.69 g respectively. The female to male ratio in the sample was 1:1.4. The male and female curves are not significantly different, but large females are slightly heavier at any given length (Table 3, Fig, 12), which becomes particularly obvious as the spawning season approaches when the females become gravid. The sex can only be determined on live fish by extruding milt or ova from the vent or in the case of rotund females. The exponents of the length - weight equations are consistently less than 3, where males and females varied from 2.8394 to 2.9098 respectively. In the closely related Two-spined Blackfish *Gapopsis bispinosus* Sanger (1990) described a linear regression relationship between length and Weight of $Log_{10} W=2.856 Log_{10} TL - 4.805$, where W = weight in g and L = total length in mm.

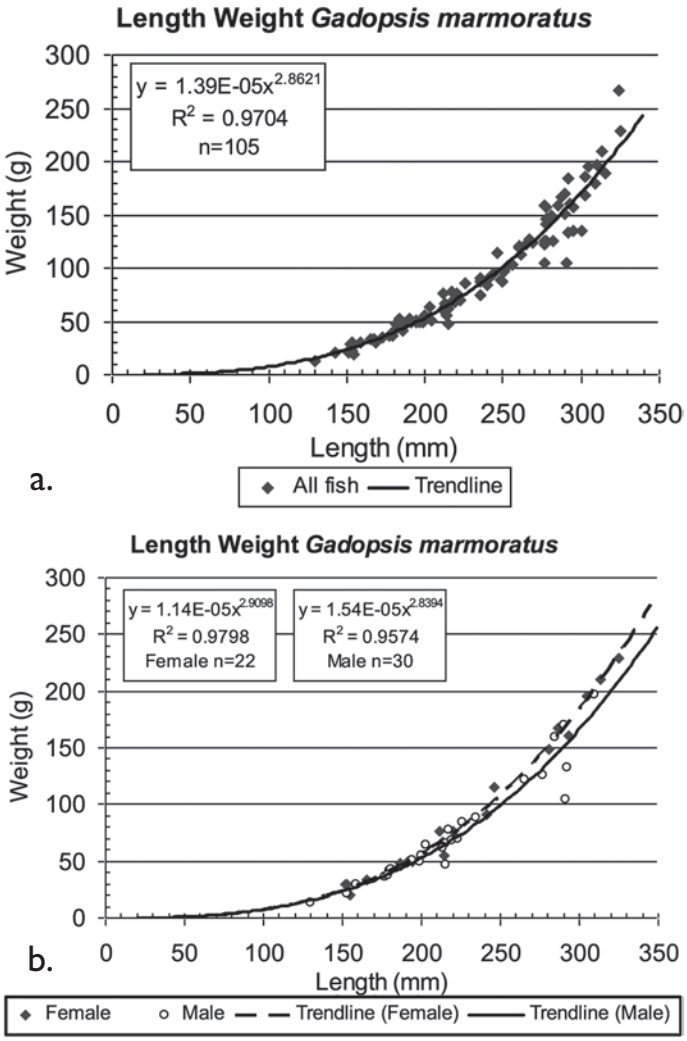


Figure 12. Length - weight relationship for *Gadopsis marmoratus* (River Blackfish). a, all fish grouped. b, males and females.

Mountain Galaxias *Galaxias olidus*

All $y=1.02E\text{-}05x^{2.8409}$

The sample of 23 *G. olidus* was collected in a tributary of the upper reaches of the Snowy River a few kilometers east of Smiggins Hole. They ranged from 44.0 to 76.5 mm in length and 0.42 to 2.18 g in weight. The mean weight and length of all fish in the sample was 0.91 g and 53.9 mm (Table 3). Fish were not sexed and the length weight relationship plot (Fig. 13) indicated the exponent value was 2.8409, below that for isometric growth.

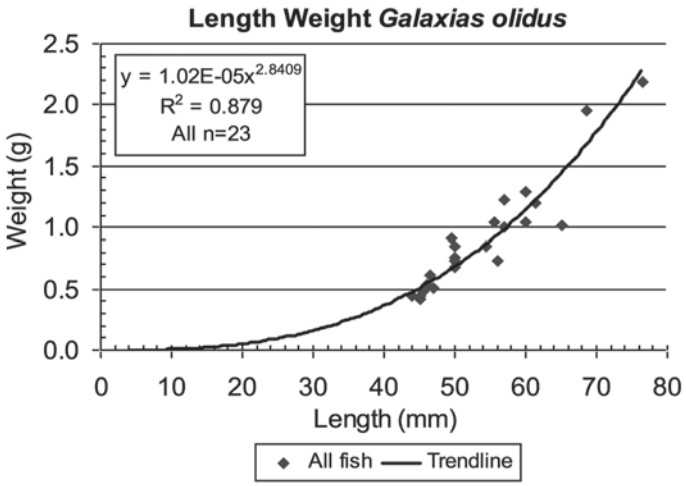


Figure 13. Length - weight relationship for *Galaxias olidus* (Mountain Galaxias). The data available is for all fish, unknown sex only.

Murray Jollytail *Galaxias rostratus*

All y=4.20E-07x$^{3.5916}$. Male y=3.83E-07x$^{3.6268}$. Female y=5.12E-07x$^{3.5438}$.

Eighteen were collected from ponds at Narrandera Fisheries Centre after being collected at Barren Box Swamp some months earlier, 5 were caught in bait traps in a dam 3km south of the Fisheries Centre (34°48'S 146°32'E) and the remainder were caught in the Narrandera area. They ranged from 52.5 to 150.0 mm in length and 0.71 to 22.52 g in weight. The mean weight and length of males and females in the sample was 5.38 g and 88.9 mm, and 6.03 g and 86.6 mm respectively (Table 3). The curves for males and females are not significantly different, but the curves for males are slightly steeper (Fig. 14). This unusual result could be magnified by the small sample size, since visual inspection of a limited number didn't indicate males were particularly gravid.

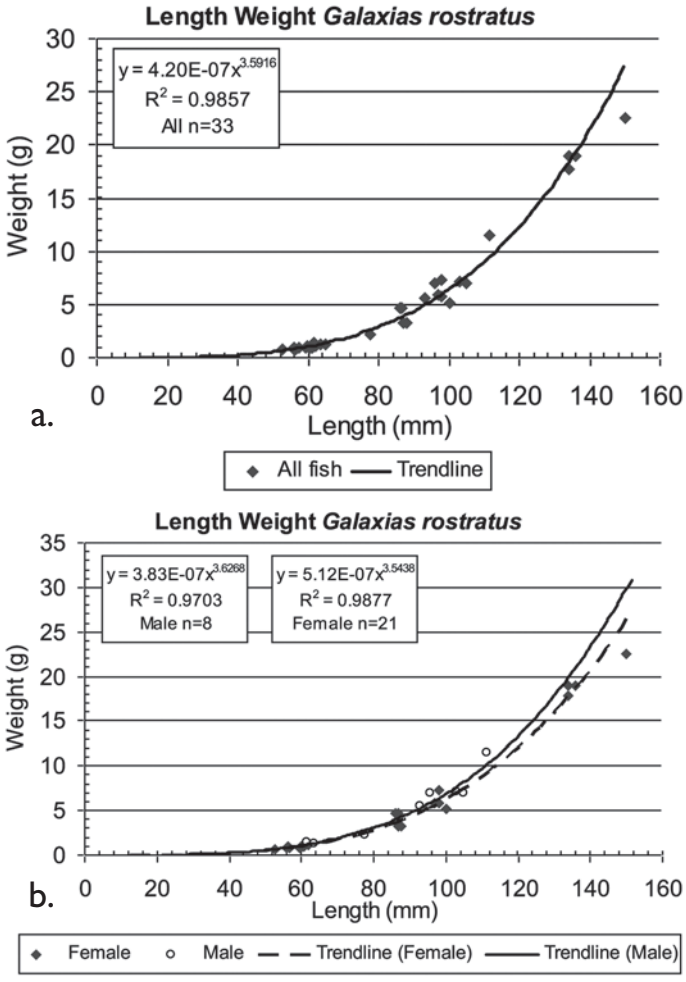


Figure 14. Length - weight relationship for *Galaxias rostratus* (Murray Jollytail). a, all fish grouped. b, males and females.

Mosquitofish *Gambusia holbrooki*

All y=6.65E-06x$^{3.1684}$. Male y=7.65E-06x$^{3.1180}$. Female y=4.11E-06x$^{3.3038}$.

Although G. *holbrooki* was abundant in the Murray - Darling River System during collection of this data in the 1960s and 70's no length weight data was collected, so a sample is included from a coastal population at Blackhead Lagoon a small lagoon situated immediately to the north of Halliday's Point village, NSW, Lat. 32°04' Long. 152°33' collected in 2006. They ranged from 11.5 to 58.0 mm in length and 0.01 to 2.62 g in weight. The mean weight and length of

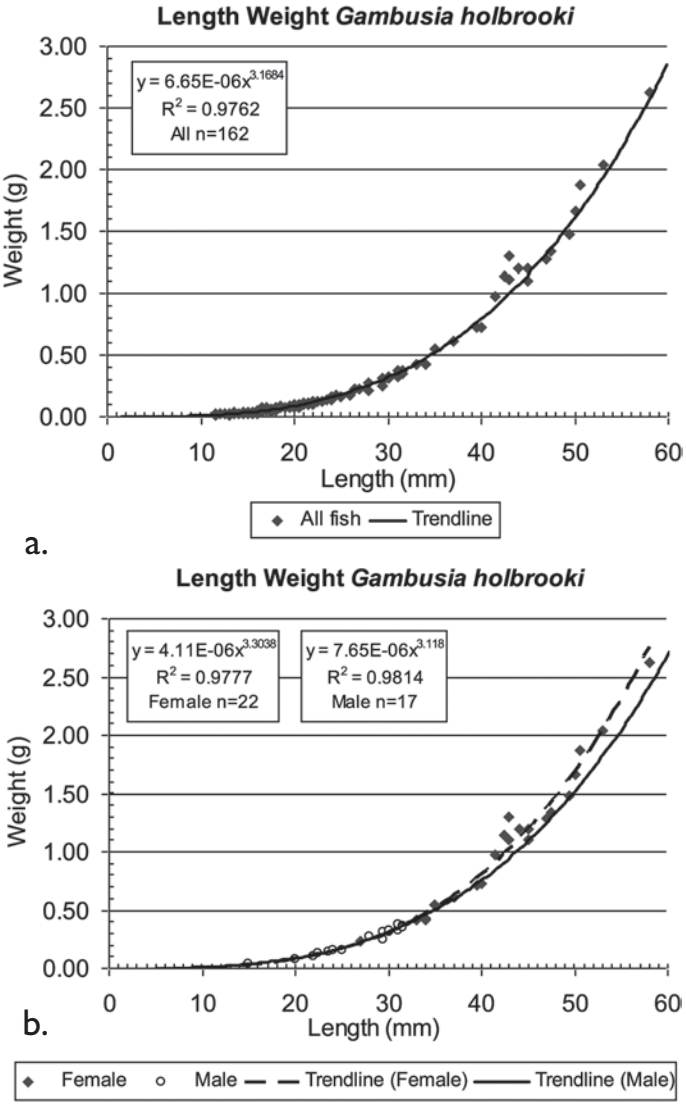


Figure 15. Length - weight relationship for *Gambusia holbrooki* (Mosquitofish). a, all fish grouped. b, males and females.

males and females in the sample was 0.23 g and 26.6 mm, and 1.11 g and 42.7 mm respectively (Table 3). The length weight curves for males and females were not significantly different, although the female curve is steeper than that for males (Fig.15). Gravid ovivivparous females when carrying developing young are clearly more rotund than males and would have influenced the significance, if more had been present in the sample. Mature females are also generally larger and grow to a greater length than do males.

Carp Gudgeons *Hypseleotris* sp.

All $y=3.51E\text{-}06x^{3.3106}$. Male $y=1.01E\text{-}05x^{3.0307}$.
Female $y=6.61E\text{-}06x^{3.1333}$.

All 133 of the *Hypseleotris* sp. were collected in ponds at the Narrandera Fisheries Centre or adjacent water bodies between 1965 and 1970. They ranged from 14.5 to 49.0 mm in length and 0.02 to 1.43 g in weight. The mean weight and length of males and females in the sample was 0.75 g and 39.6 mm, and 0.45 g and 34.4 mm respectively (Table 3). There was no significant difference between the length weight curves in the available sample (Fig. 16). However mature males in some species in this genus are substantially larger than females and can be recognized at breeding by the hump on the forehead just behind the eyes. This should cause the curve for males to swing further to the left than in females as it does in *Mogurnda adspersa* (Fig. 23). Pusey *et al.* (2004) from unpublished data involving 559 *Hypseleotris klunzingeri* found a length weight relationship of $W=6x10^{-6}L^{3.318}$, $r^2=0.957$ $p<0.001$ for fish from the Mary River. (W=g and L=standard length in mm) The exponent is almost identical to that found in this study for all fish 3.3106.

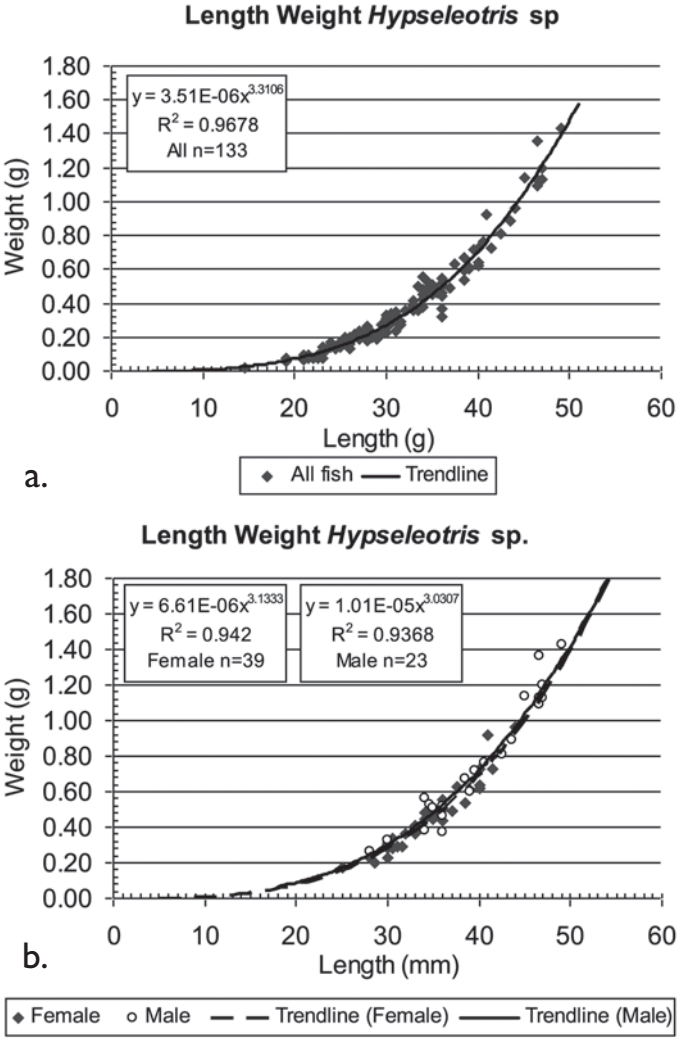


Figure 16. Length - weight relationship for *Hypseleotris* sp (Carp Gudgeon). a, all fish grouped. b, males and females.

Spangled Perch *Leiopotherapon unicolor*

All $y=2.62E\text{-}06x^{3.3838}$. Male $y=5.45E\text{-}06x^{3.2200}$.
Female $y=5.66E\text{-}06x^{3.2321}$.

All specimens were collected using a haul net at Leg of Mutton Dam, a water supply dam for Tottenham which is 125km north of Condobolin Lat 32°13.6'S Long147°21.8'E. They ranged from 30 to 252 mm in length and 0.1 to 270 g in weight. The mean weight and length of males and females in the sample was 18.80 g and 103.7 mm, and 33.48 g and 118.5 mm respectively (Table 3). The length weight curves for males and females are significantly different (Fig.17b). The steeper curve for females indicates they are more rotund than males particularly when ovaries are enlarged. Pusey *et al.* (2004) provides five examples of Length Weight relationships from Northern Territory and Queensland samples (Bishop *et al.* 2001, Pusey *et al.*2004

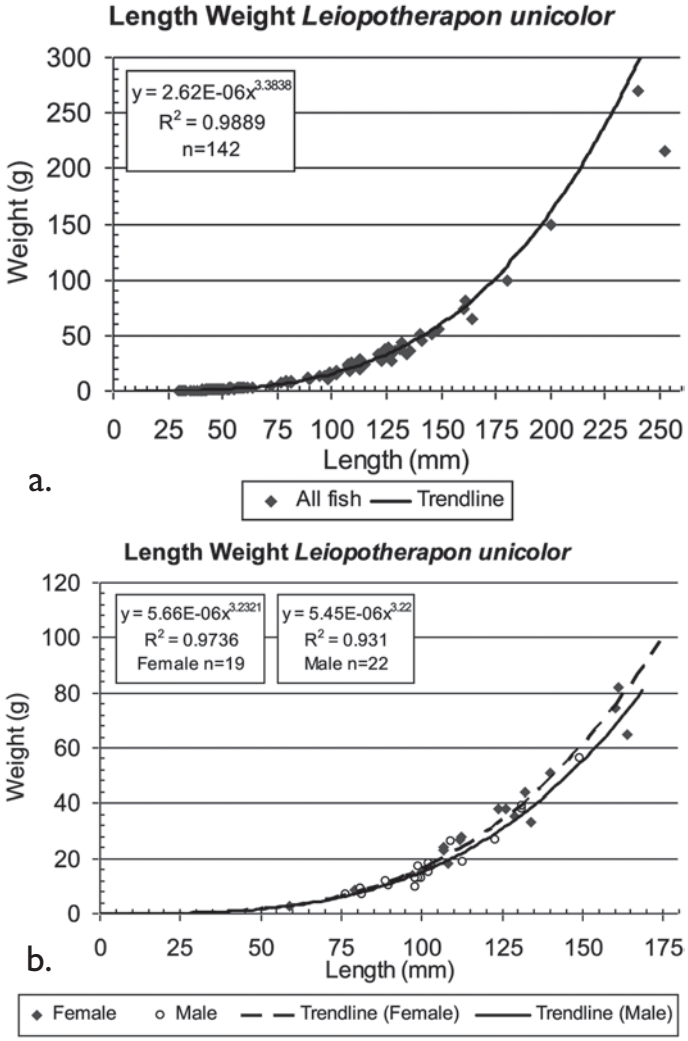


Figure 17. Length - weight relationship for *Leiopotherapon unicolor* (Spangled Perch). a, all fish grouped. b, males and females.

unpublished data, Arthington *et al.* 1992a, Blühdorn and Arthington 1994) based on standard length and caudal fork length. The exponents lie between 2.936 and 3.06 which in all cases are lower than 3.3838 for fish in this sample, which are based on total length measurements.

Trout Cod *Maccullochella macquariensis*

All $y=7.15E\text{-}05x^{2.7492}$

Five *M. macquariensis* were measured from fish taken downstream of Yarrawonga Weir on the Murray River and one taken in the Wakool River near Wakool. They ranged from 280 to 610 mm in length and 339 to 3629 g in weight. The mean weight and length of all fish in the sample was 1337 g and 406 mm (Table 3). No data was available to compare sex differences. The length weight relationship plot (Fig. 18) indicated the exponent value was 2.7492 and that growth was allometric.

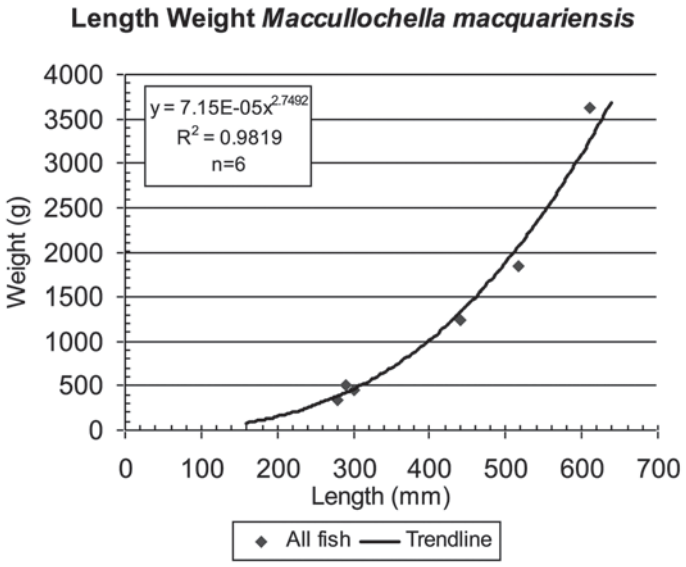


Figure 18. Length - weight relationship for *Maccullochella macquariensis* (Trout Cod). The data available is for all fish, unknown sex only.

Murray Cod *Maccullochella peelii peelii*

All $y=2.75E\text{-}06x^{3.2848}$. Male $y=1.96E\text{-}06x^{3.3344}$. Female $y=8.67E\text{-}06x^{3.1129}$.

The sample of *M. peelii peelii* was taken from the Murray, Murrumbidgee, Lachlan and Darling River systems between 1958 and 1972 by various fishing methods (usually set lines, drum nets and gill nets). They ranged from 88 to 1295 mm in length and 7 to

34020 g in weight. The mean weight and length of males and females in the sample was 8375g and 723 mm, and 8380 g and 731 mm respectively (Table 3). The general shape of the curve (Fig. 19 and Table 3) is similar for males, and all data combined. The curves for males and females are not significantly different, but the male curve is slightly steeper particularly for males over 20 kg. Fish over this size frequently have large amounts of fat and if females mobilize greater quantities during maturation of gonads it is finally lost at spawning. This could account for the less steep curve in females. The male to female ratio in the sample was 1:2.3. Although this ratio may not reflect what is found in the wild, it does indicate a predominance of females unlike that in *M. ambigua* and *B. bidyanus*. The exponent of the length - weight equation for all fish combined (3.2848) is above 3, the value for isometric growth. In practice it is often difficult to use shape as a method of discriminating the sexes in this species. The relationship was very similar to that found by Rowland (1998) $W=3.240 \times 10^{-9} \times L^{3.2592}$ where L = length in mm and W = weight in kg.

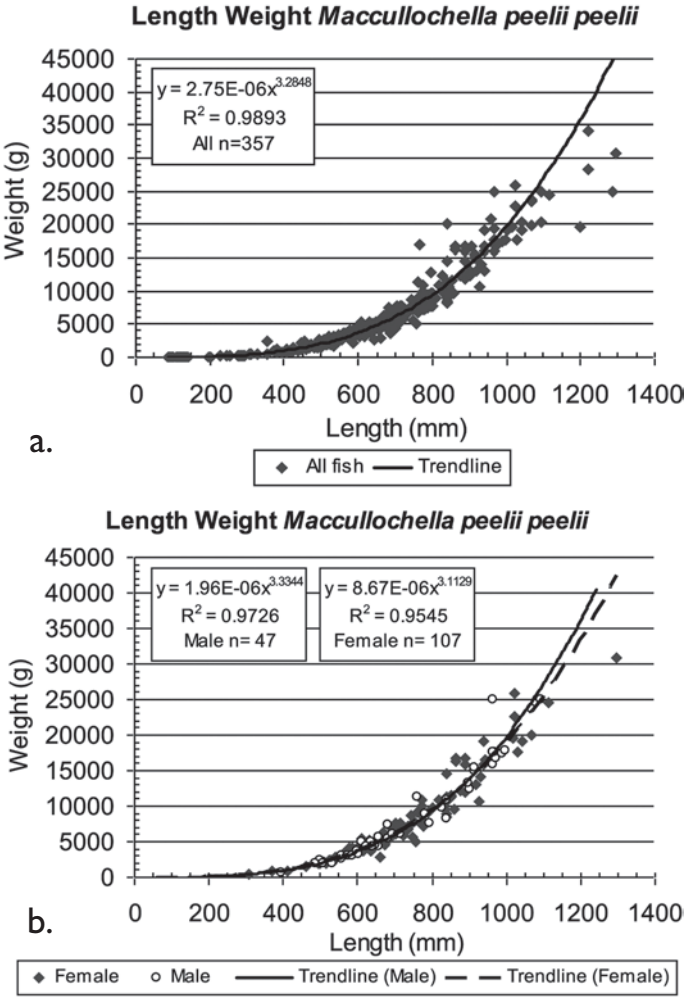


Figure 19. Length - weight relationship for *Maccullochella peelii peelii* (Murray Cod). a, all fish grouped. b, males and females.

Golden Perch *Macquaria ambigua*

All $y=7.08E\text{-}06x^{3.1246}$. Male $y=1.33E\text{-}06x^{3.4020}$. Female $y=5.29E\text{-}07x^{3.5652}$.

Comparisons here are confined to all males, all females and all fish grouped together including unsexed fish. From the 2378 fish used, 1019 were caught by drum nets during a tagging program along the Murrumbidgee River, 574 from the Narrandera area, 432 around Hay and 13 around Balranald. A further 1200 were from fish of all sizes successfully bred in ponds at the Narrandera Fisheries Centre, and the remaining 159 were from various locations such as 65 from Lachlan River west of Forbes, 31 from Menindee Lakes, 16 from Yetman, the Macintyre River etc. Fish ranged in length and weight from 9.5 to 635 mm and 0.02 to 5387 g respectively.

The mean weights and lengths of males and females in the sample were 1279 g and 423mm, and 1902g and 456mm respectively (Table 3), and the females were much larger than males. The length weight curves for males and females were significantly different. The female curves were steepest (Fig. 20), gravid females being much more rotund than males and enabling them to be easily sexed when approaching spawning. The sex ratio of females to males in the sample was 1:3.1 The large sexed fish from the sample had exponent values of 3.4020 for males and 3.5652 for females but when the large number of small unsexed fish were lumped together the exponent value fell to 3.1246. Jones (1974) obtained a length weight relationship of $W=3.34x10^{-6}TL^{3.45}$ (TL in cm and W in g) from 110 fish taken at Renmark and west in the Murray River, and Anderson *et al*. (1992) obtained a relationship of $W= 3.34x10^{-7}L^{3.66}$ (L in mm W in g) (size range 100-600mm in length) from 881 fish in rivers flowing into the Murray from the south The exponents here were similar to the large sexed fish in this study, but the 550 fish less than 100 mm in length which were included in the data for all fish, resulted in the exponent dropping to 3.1246.

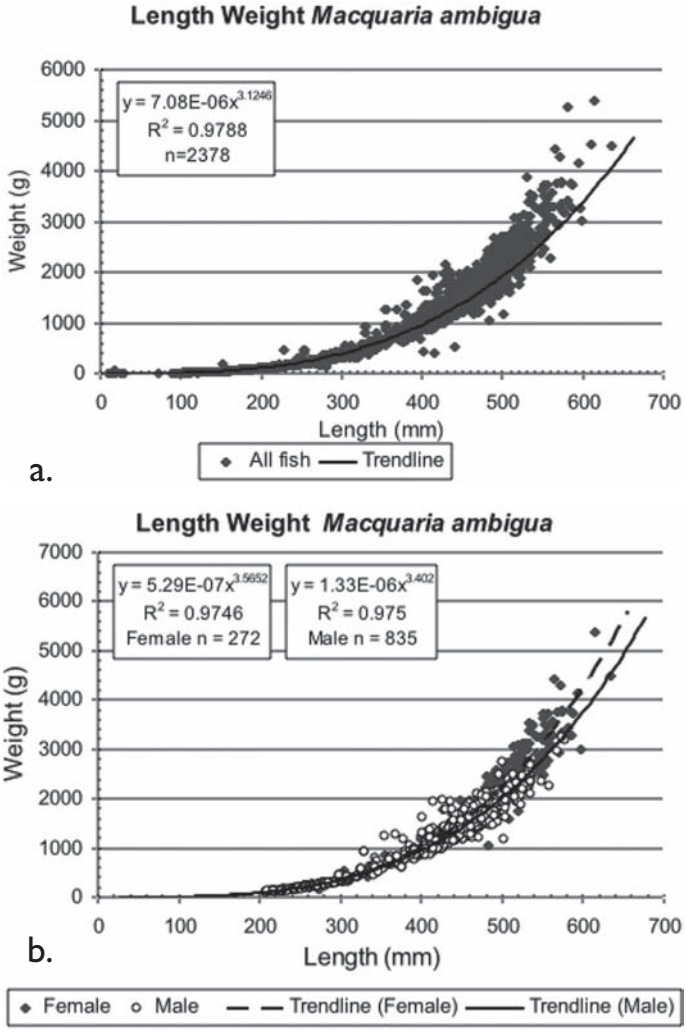


Figure 20. Length - weight relationship for *Macquaria ambigua* (Golden Perch). a, all fish grouped. b, males and females.

Macquarie Perch *Macquaria australasica*

All $y=0.000472x^{2.4110}$.

Of the 27 M. *australasica* collected 13 were from Burrinjuck Dam in the Goodradigbee arm near Wee Jasper, 2 near Goodhope 14km SW of Yass, 2 from Wyangala Dam and 10 from various other localities. They ranged from 178 to 508 mm in length and 107 to 1701 g in weight. The mean weight and length of all fish in the sample was 580 g and 323 mm (Table 3). The length weight relationship plot (Fig. 21) indicated the exponent value was 2.4110 and that growth was markedly allometric

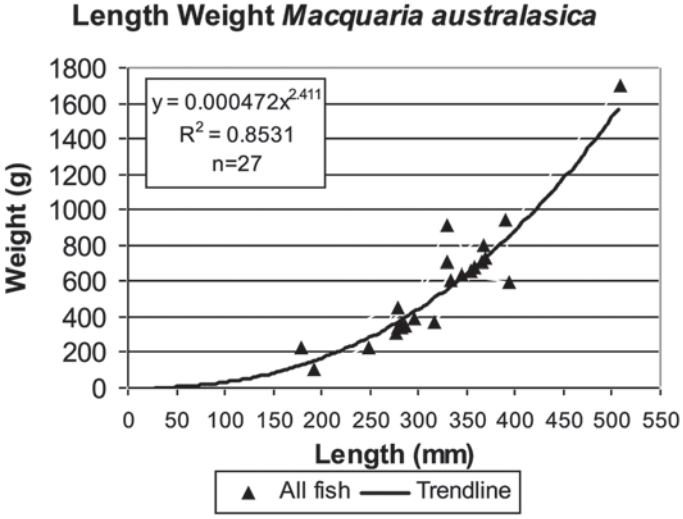


Figure 21. Length - weight relationship for *Macquaria australasica* (Macquarie Perch). The data available is for all fish, unknown sex only.

Murray River Rainbowfish *Melanotaenia fluviatilis*

All $y=1.26E\text{-}05x^{2.9180}$.

Eight of the M. *fluviatilis* were collected from the Darling River system and eight from Narrandera and downstream along the Murrumbidgee River. Some discussion exists as to possible differences between Darling River fish and the Murrumbidgee and Murray River fish (Lloyd 1988, Romanowski 1989), a view I support. However these data have been lumped together because of the limited material at hand. They ranged from 46.0 to 88.0 mm in

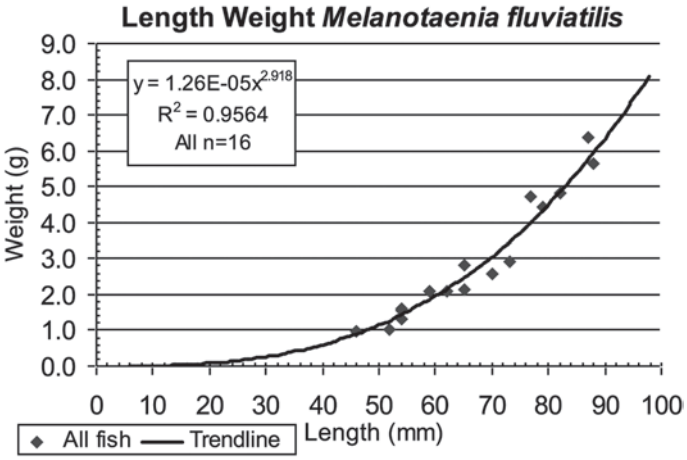


Figure 22. Length - weight relationship for *Melanotaenia fluviatilis* (Murray River Rainbowfish). The data available is for all fish, unknown sex only.

length and 0.97 to 6.38 g in weight. The mean weight and length of all fish in the sample was 2.94 g and 66.7 mm (Table 3). The length weight relationship plot (Fig.22) indicated the exponent value was 2.9180 and that growth was close to isometric.

Purple-spotted Gudgeon *Mogurnda adspersa*

All $y=3.50E\text{-}06x^{3.2632}$. Male $y=2.51E\text{-}06x^{3.3565}$. Female $y=8.66E\text{-}06x^{3.0449}$.

All 70 specimens originated from fish collected at Barren Box Swamp, (34°11'S 145°50'E) situated 22 km west-north-west of Griffith between 1965 and 1970, and many were kept and subsequently bred at the Narrandera Fisheries Centre. They ranged from 31.1 to 94.0 mm in length and 0.27 to 11.16 g in weight. The mean weight and length of males and females in the sample was 2.09 g and 57.4 mm, and 2.75 g and 62.4 mm respectively (Table 3). The slopes of the curves for males and females were initially not significantly different, but when one suspect outlier was removed the difference was highly significant. The curve for males was steepest (Fig. 23), which reflects the large bull head of the male which develops in the large adult males. Pusey *et al*. 2004 reports the length weight relationship for Mary River fish as $W=1.0x10^{-5}SL^{3.197}$, $r^2=0.990$, n=136 and for Wet Tropics fish $W=5.093x10^{-6}SL^{3.394}$, $r^2=0.948$, n=178. The exponential value of 3.2632 for all fish in this study falls between these two values.

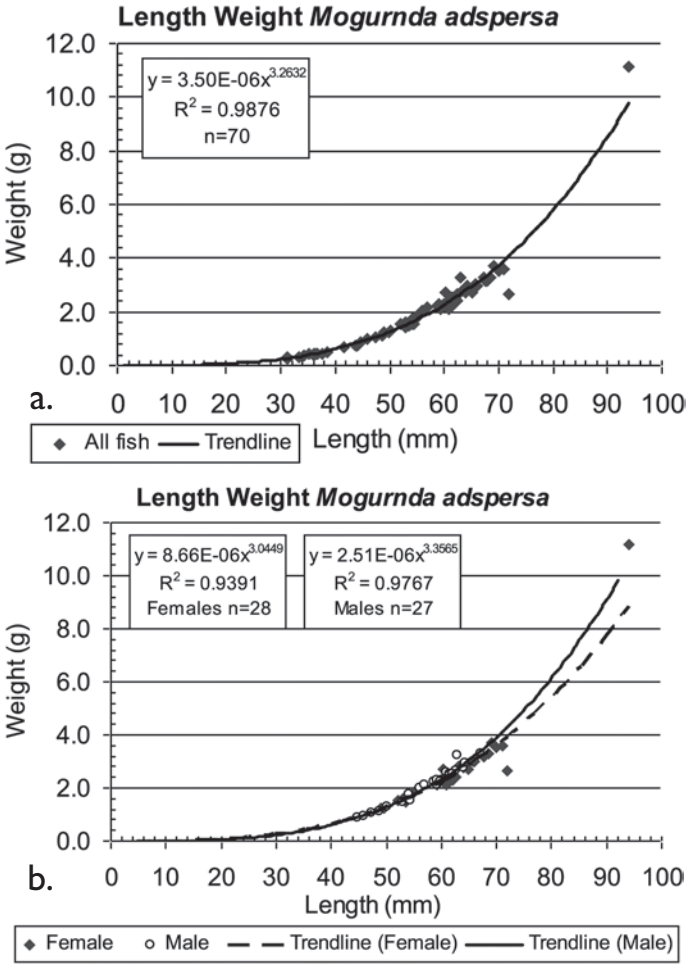


Figure 23. Length - weight relationship for *Mogurnda adspersa* (Purple-spotted Gudgeon). a, all fish grouped. b, males and females.

Southern Pygmy Perch *Nannoperca australis*

All $y=8.26E\text{-}06x^{3.1273}$. Male $y=4.98E\text{-}06x^{3.2549}$. Female $y=2.75E\text{-}05x^{2.8366}$.

All the 149 *N. australis* were captured or bred from fish taken at Barren Box Swamp (34°11'S and 145°50'E) between 1966 and 1968. Many were kept in ponds at the Narrandera Fisheries Centre. They ranged from 23.1 to 63.0 mm in length and 0.15 to 3.48 g in weight. The mean weight and length of males and females in the sample was 1.29 g and 45.1 mm, and 1.84 g and 48.6 mm respectively (Table 3). The slopes of length - weight curves for male and female were significantly different (Fig. 24). Females up to around 55mm in length are more rotund brought about probably by noticeably gravid females during the breeding period. However in large fish in this sample there is little difference in the curves suggesting that large females did not breed. Larger samples are needed to substantiate whether large females breed in other populations.

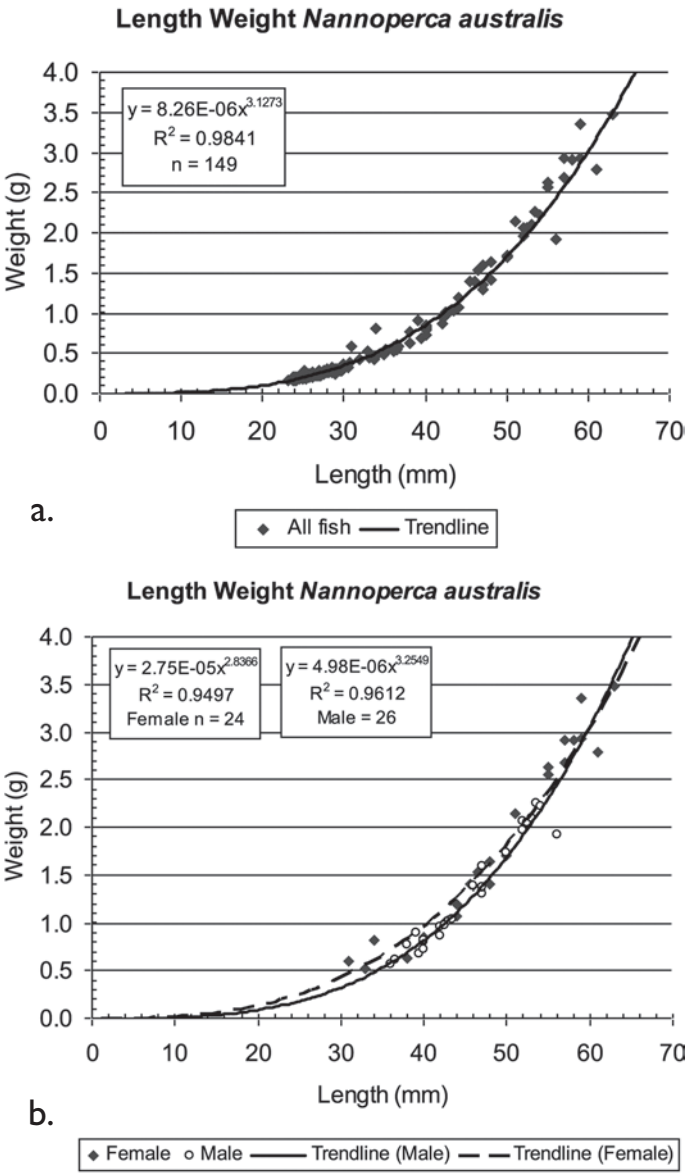


Figure 24. Length - weight relationship for *Nannoperca australis* (Southern Pygmy Perch). a, all fish grouped. b, males and females.

Bony Bream *Nematalosa erebi*

All $y=1.45E\text{-}06x^{3.3403}$. Male $y=3.97E\text{-}07x^{3.5975}$.
Female $y=1.97E\text{-}05x^{2.9044}$.

Samples of this species were taken from Moomin Creek 75 km east of Collarenebri (105) and in the Coleambally Canal and west along the Murrumbidgee River (21). They ranged from 218 to 444 mm in length and 85 to 1070 g in weight. The mean weight and length of males and females in the sample was 244g and 275 mm, and 289g and 287mm respectively (Table 3). The length weight curves for males and females (Fig. 25) are similar and are not significantly different, but plots do suggest large males above 300 mm may be heavier at a given length than females. Confirmation of this is required from large fish. The length weight relationships are listed by Bishop *et al.* (2001) from the Alligator River NT (Caudal fork length (CFL) in cm, W in g) as $W=0.012CFL^{3.32}$, n=845, $r^2=1.0$, by Harris and Gehrke (1997) from inland NSW (CFL in mm, w in g) as $W=0.862x10^{-5}CFL^{3.1227}$ and by Arthington *et al.*(1992b) from the Burnet River Queensland (Standard length (SL) in cm, W in g) as $W=0.017SL^{3.113}$, n=1223, $r^2= 0.964$. The exponent from inland fish in this study for all fish is 3.3403 based on total length, which is slightly higher than reported by other workers..

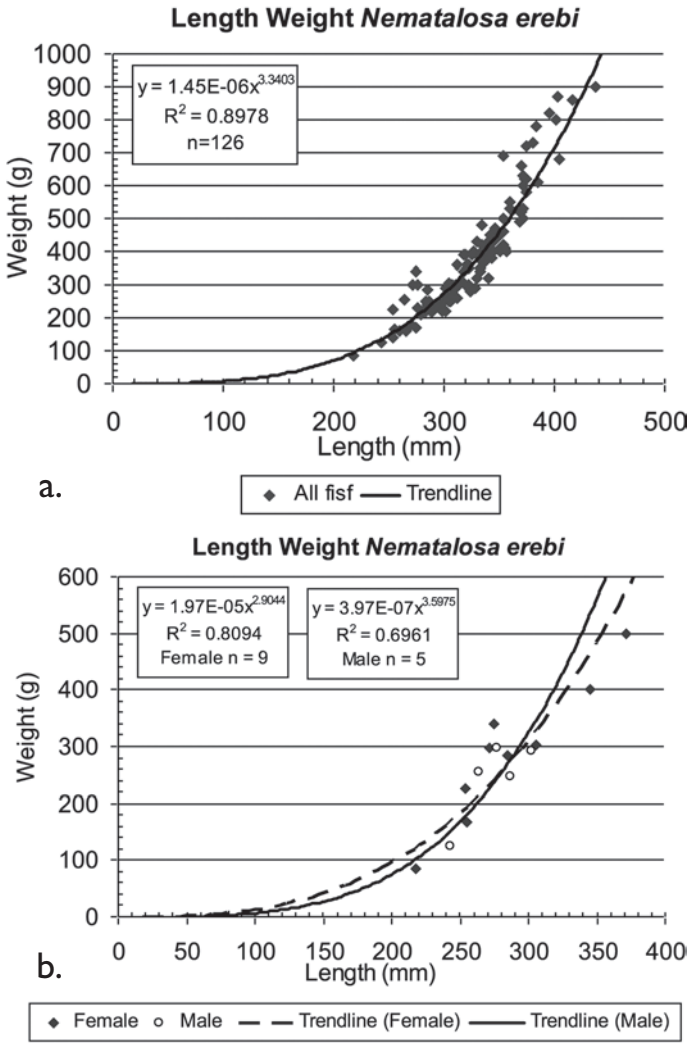


Figure 25. Length - weight relationship for *Nematalosa erebi* (Bony Bream). a, all fish grouped. b, males and females.

Rainbow Trout *Oncorhynchus mykiss*

All $y=2.39E\text{-}05x^{2.8557}$. Male $y=2.92E\text{-}05x^{2.8192}$.
Female $y=2.51E\text{-}05x^{2.8428}$.

In the sample used, 269 were from Wollondibby Creek, 53 from Lake Jindabyne and 10 from Thredbo River near Gaden Trout Hatchery, all from the same population in eastern flowing streams, 25 were from Lake Canobolas, and the remaining 9 from various localities. They ranged from 72 to 547 mm in length and 4 to 1871 g in weight. The mean weight and length of males and females in the sample was 153 g and 197 mm, and 268 g and 239 mm respectively (Table 3). No significant difference in the male and female length weight curves were apparent (Fig. 26). The female to male sex ratio in the sample was 1:1.8.

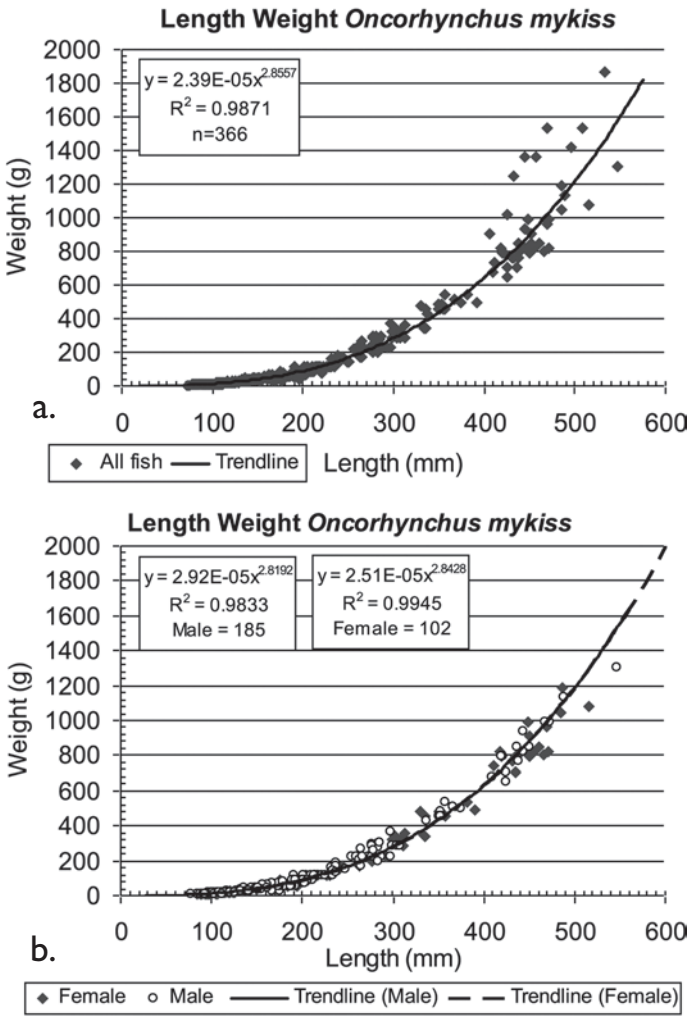


Figure 26. Length - weight relationship for *Oncorhynchus mykiss* (Rainbow Trout). a, all fish grouped. b, males and females.

English Perch *Perca fluviatilis*

All $y=2.47E\text{-}06x^{3.3127}$. Male $y=1.96E\text{-}06x^{3.3421}$.
Female $y=1.42E\text{-}06x^{3.4117}$.

English perch samples were from the eastern flowing Saucy Creek near Bombala (37°00'S 149°15'E) (49), and from western flowing waters in Blowering Dam (553), Murrumbidgee River (37), Colombo and Billabong Creek (32), Murray River (20) and the rest spread around southern New South Wales. Fish were caught throughout the year by gill netting and they ranged in length and weight from 51

to 492 mm and 7 to 2110 g respectively. The mean weights and lengths of males and females in the sample were 253 g and 231mm, and 422g and 259mm respectively (Table 3), the females being much larger than males. The male to female ratio in the sample was 1:1.57. The slope of the curve for females was steeper than for males (Fig. 27) and they were significantly different. However, the shape of this species does not generally assist in determining sex even when females are gravid. The rigid body scales covering *P. fluviatilis* probably restricts any obvious shape change during gonad development. The value of the exponent in the length - weight equation was above 3 in males, females and all fish indicating that growth was allometric.

Le Cren (1951) obtained exponent values for mature and immature male English perch over 1 year old of 3.28063 and 3.24253 respectively compared with 3.3421 for males in this study. However in females he obtained values of 3.19506 and 3.39938 for immature and mature females respectively, compared with 3.4117 for all females grouped together in this study.

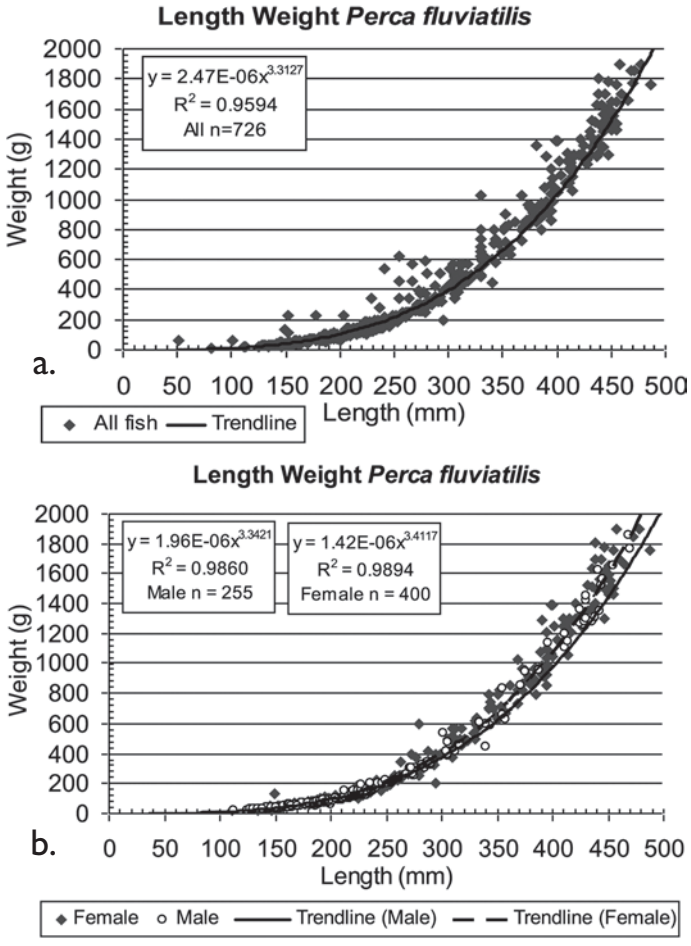


Figure 27. Length - weight relationship for *Perca fluviatilis* (English Perch). a, all fish grouped. b, males and females.

Flat-headed Gudgeon *Philypnodon grandiceps*

All $y=3.85E\text{-}06x^{3.1858}$. Male $y=4.00E\text{-}09x^{4.7690}$. Female $y=4.14E\text{-}06x^{3.1719}$.

The sample of *P. grandiceps* contained 18 fish from Prospect Reservoir west of Sydney and one from Renmark on the Murray River. They ranged from 44.0 to 110.0 mm in length and 0.68 to 13.32 g in weight. The mean weight and length of males and females in the sample was 3.57 g and 74.8 mm, and 5.01 g and 76.4 mm respectively (Table 3). The curves for males and females from the sample were non significantly different, which was influenced by the lack of large males above 80mm. Males in this species above 80 mm in length had a markedly steeper curve than the females (Fig. 28), indicating they were noticeably heavier than females of equal length. This agrees with the large head and bulbous cheeks seen in adult males which are much larger than in females of equal length. Pusey *et al.* (2004) recorded the length weight relationship for this species in the Mary and Albert Rivers in SE Queensland as $W=0.8x10^{-5}SL^{3.227}$, r=0.964, n=769. This is very close to the exponent value of 3.1858 for all fish found in this study.

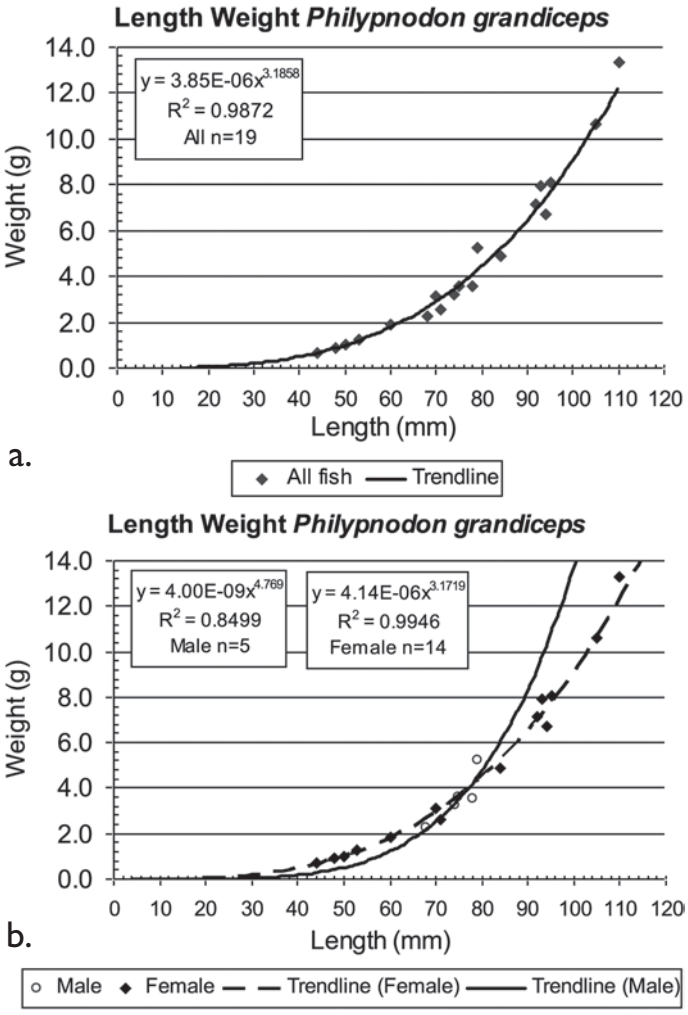


Figure 28. Length - weight relationship for *Philypnodon grandiceps* (Flat-headed Gudgeon). a, all fish grouped. b, males and females.

Australian Smelt *Retropinna semoni*

All $y=4.12E\text{-}06x^{3.1062}$.

The 13 *R. semoni* were collected from Billabong Creek near Walbundrie 47km NW of Albury in 1965. They ranged from 32.0 to 88.0 mm in length and 0.18 to 4.00 g in weight. The mean weight and length of all fish in the sample was 1.51 g and 58.4 mm (Table 3). They were not sexed. The length weight relationship

plot (Fig. 29) indicated the exponent value was 3.1062 and that growth was allometric. In this species it is not generally possible to differentiate between the sexes even when gravid females are present. Pusey *et al.* (2004) from unpublished data involving 475 fish, found a length weight relationship of $W=0.5x10^{-5}SL^{3.227}$, $r^2=0.956$, $p<0.001$ for fish from the Mary River (W=g and SL=standard length in mm). The exponent is slightly higher than that found in this study.

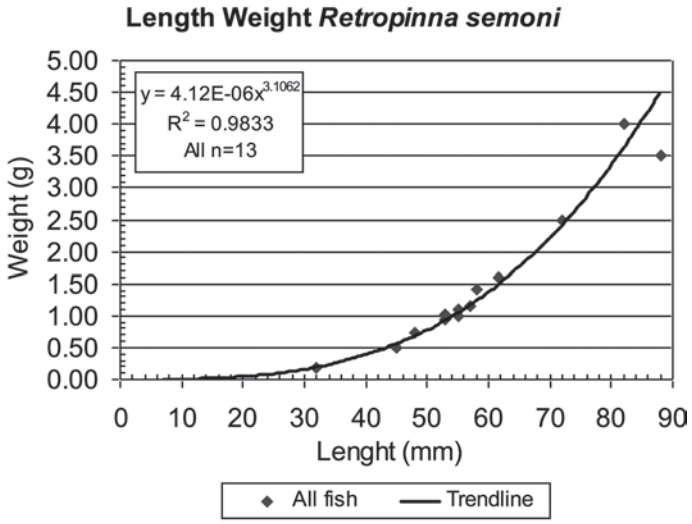
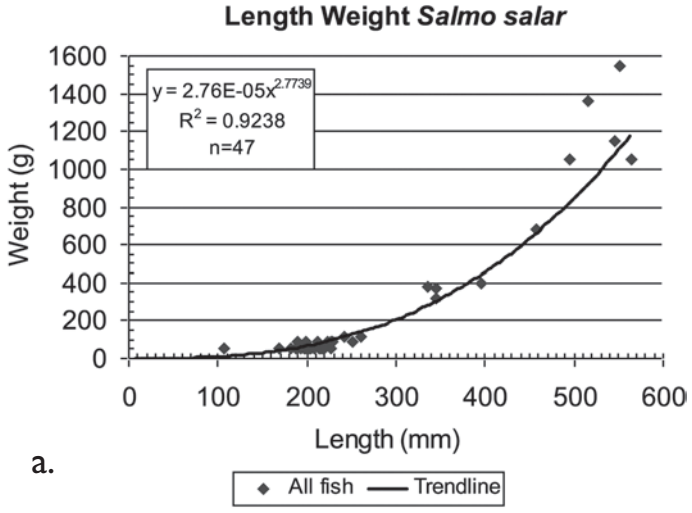


Figure 29. Length - weight relationship for *Retropinna semoni* (Australian Smelt). The data available is for all fish, unknown sex only.

Atlantic Salmon *Salmo salar*

All $y=2.76E\text{-}05x^{2.7739}$. Male $y=1.53\text{-}05x^{2.8904}$.
Female $y=8.66E\text{-}06x^{2.9765}$.

All the *S. salar* that were measured were fish from Gaden Trout Hatchery, Jindabyne, mostly pond fish with a few from those released into Lake Jindabyne. They ranged from 107 to 565 mm in length and 57 to 1550 g in weight. The mean weight and length of males and females in the sample was 498 g and 357 mm, and 935 g and 473 mm respectively (Table 3). Length weight curves for male and female were very similar and were not significantly different. (Fig. 30).



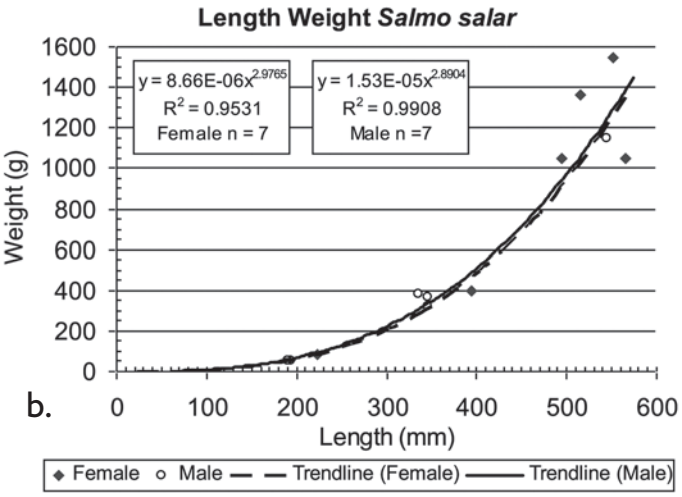
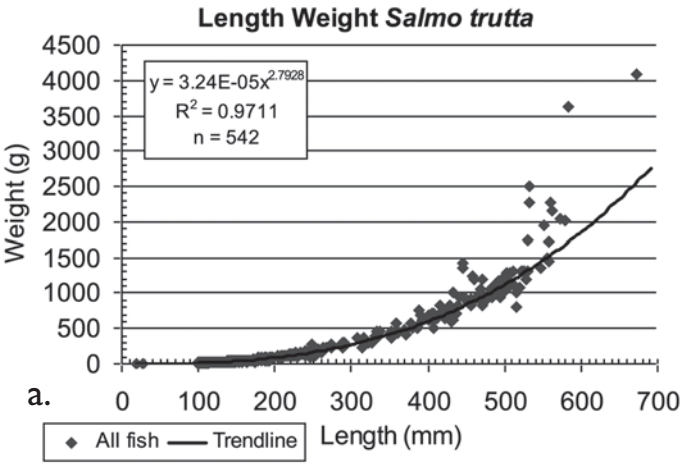


Figure 30. Length - weight relationship for *Salmo salar* (Atlantic Salmon). a, all fish grouped. b, males and females.

Brown Trout *Salmo trutta*

All $y=3.24E\text{-}05x^{2.7928}$. Male $y=1.94E\text{-}05x^{2.8905}$.
Female $y=2.10E\text{-}05x^{2.8714}$.

The sample for *S. trutta* contained 316 fish from Wollondibby Creek, 102 from Lake Jindabyne and 12 from Thredbo River from the same population; 102 from Lake Canobolas and 10 from other localities. They ranged from 19 to 673 mm in length and 3 to 4082 g in weight. The mean weight and length of males and females in the



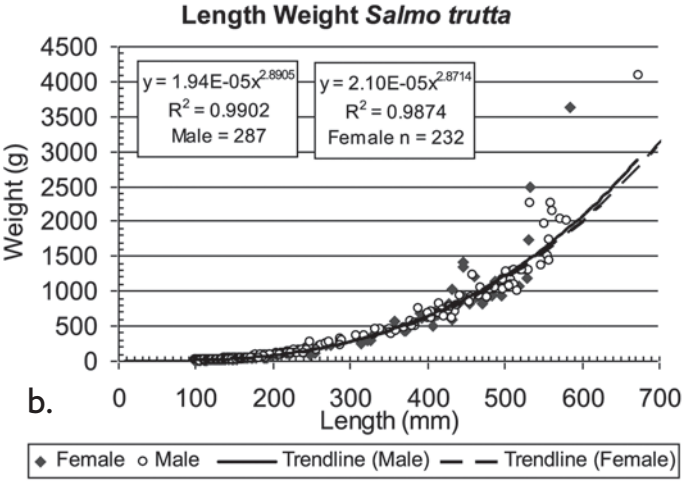


Figure 31. Length - weight relationship for *Salmo trutta* (Brown Trout). a, all fish grouped. b, males and females.

sample was 297 g and 229 mm, and 277 g and 226 mm respectively (Table 3). The female to male sex ratio was 1:1.2. The curves for female and male were very similar and were not significantly different (Fig. 31) showing no indication of greater rotundness in females which is usually the case (pers. obs.).

Brook Char *Salvelinus fontinalis*

All $y=1.35E\text{-}05x^{2.9548}$. Male $y=1.57E\text{-}05x^{2.9289}$. Female $y=1.30E\text{-}05x^{2.9761}$.

In the sample of *S. fontinalis* 82 were obtained from Wollondibby Creek (36°24.8'S, 148°34.4'E), four from Lake Canobolas 8km west of Orange and two from the Thredbo River at Gaden Trout Hatchery, Jindabyne. The original stock of all these fish was from Gaden Trout Hatchery. They ranged from 55 to 394 mm in length and 3 to 624 g in weight. The mean weight and length of males and females in the sample was 48 g and 137 mm, and 121 g and 200 mm respectively (Table 3). The male to female sex ratio was 1:1.4. Of the salmonid species examined the length weight curves of this species (Fig. 32) showed the greatest male female difference even though differences were still not significant. The female is slightly more rotund than the male. The exponent value of 2.9548 is very close to the value for isometric growth.

Freshwater Catfish *Tandanus tandanus*

All $y=5.88E\text{-}06x^{3.1007}$. Male $y=2.42E\text{-}06x^{3.2465}$. Female $y=1.43E\text{-}06x^{3.3369}$

The *T. tandanus* sample was obtained from Narrandera (146), Barren Box Swamp (55), Lakes Wyangan near Griffith (26) and the remainder from Dumersq River in the north to Wakool River in the south, and Burrendong and Wyangla Dams. Most were caught using gill nets. They ranged from 44 to 610 mm in length and 1 to 3090 g in weight. The mean weight and length of males and females in the sample was 765 g and 384 mm, and 975 g and 422 mm respectively (Table3). The curves for male and female were very similar (Fig. 33) and were not significantly different. Length weight relationships are recorded (SL mm, W g) by Pusey *et al.* (2004) as $W=1.18x10^{-4}L^{2.645}$, $r^2=0.554$, n=215 for the Wet Tropics, by Arthington *et al.* (1992a) as $W=4.0x10^{-3}SL^{3.329}$, $r^2=0.953$, n=199. by Blühdorn and Arthington (1994) as $W=4.4x10^{-6}SL^{3.244}$, $r^2=0.997$, n=242 for the Burnet River, and Davis (1977) for all fish as $W=2.96x10^{-6}TL^{3.223}$, $r^2=0.992$, n=858 for the Gwydir River. Davis (1977) also obtained exponent values for males and females of 3.202 and 3.212 respectively compared with 3.2465 and 3.3369 in this study. He found that a parabolic curve relationship was better for fish larger than 350mm.

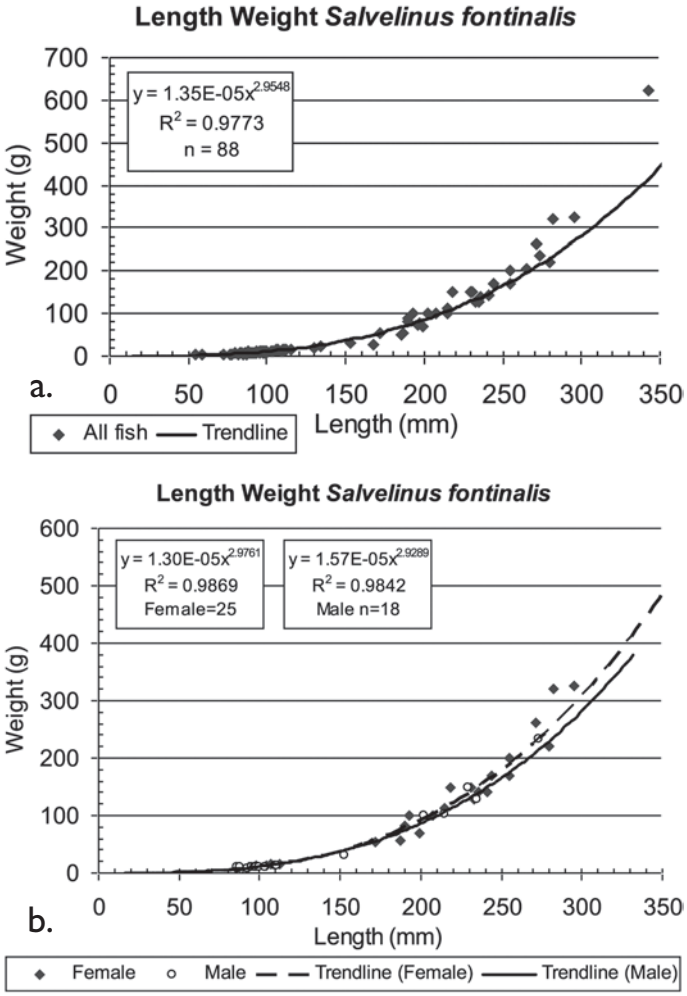


Figure 32. Length - weight relationship for *Salvelinus fontinalis* (Brook Char). a, all fish grouped. b, males and females.

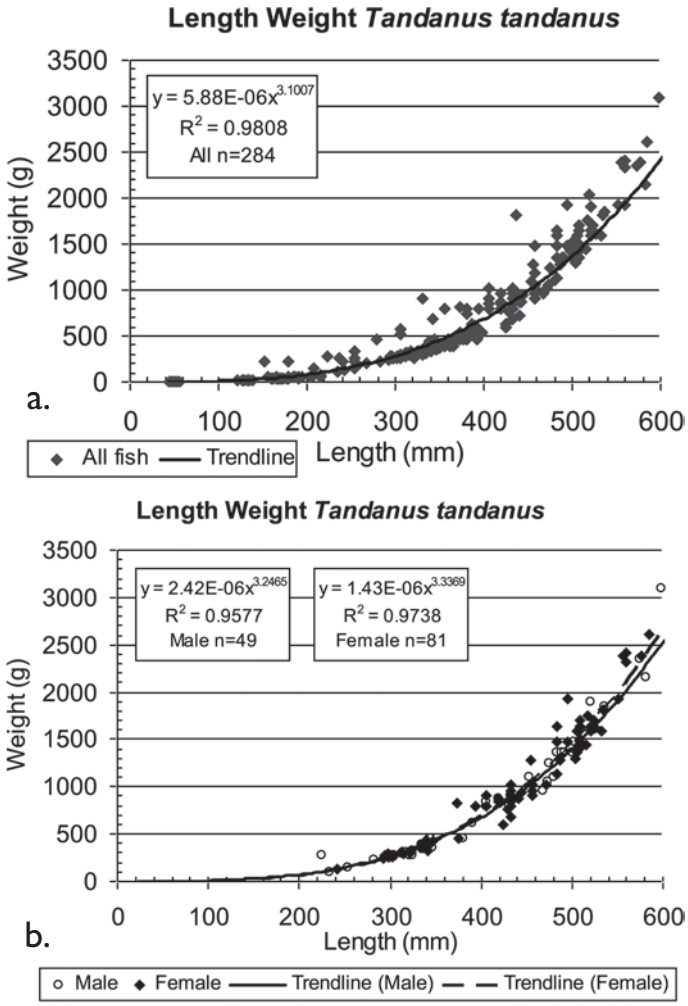


Figure 33. Length - weight relationship for *Tandanus tandanus* (Freshwater Catfish). a, all fish grouped. b, males and females.

Apart from the Wet Tropics figure in which the exponent figure is very low; all the above figures are slightly above the value of 3.1007 that are recorded here. *T. tandanus* can be sexed by the shape of the urinogenital papilla which is triangular in females and long and cylindrical in males.

Tench *Tinca tinca*

All $y=9.82E\text{-}06x^{3.0797}$. Male $y=1.98E\text{-}06x^{3.3395}$. Female $y=3.96E\text{-}06x^{3.2229}$.

The *T. tinca* were collected using gill nets at Oxley, Lachlan River (54); Yanga Lake, Balranald (18); the lower Murray River (3) and the remainder within 100 km of Narrandera. They ranged from 210 to 528 mm in length and 106 to 2466 g in weight. The mean weight and length of males and females in the sample was 1414 g and 444 mm, and 1606 g and 459 mm respectively (Table 3), the females being slightly heavier. The male and female ratio in the sample was1:1.96 showing a preponderance of females. The curves for males and females are very similar (Fig. 34) and are not significantly different. Although ventral fins are smaller and shorter in mature females when compared with males, there is no other obvious shape difference between the sexes, or marked swelling of the abdomen during gonad development. The value of the exponent (3.0797) in the length - weight equation for all fish is fairly close to 3, the value for isometric growth.

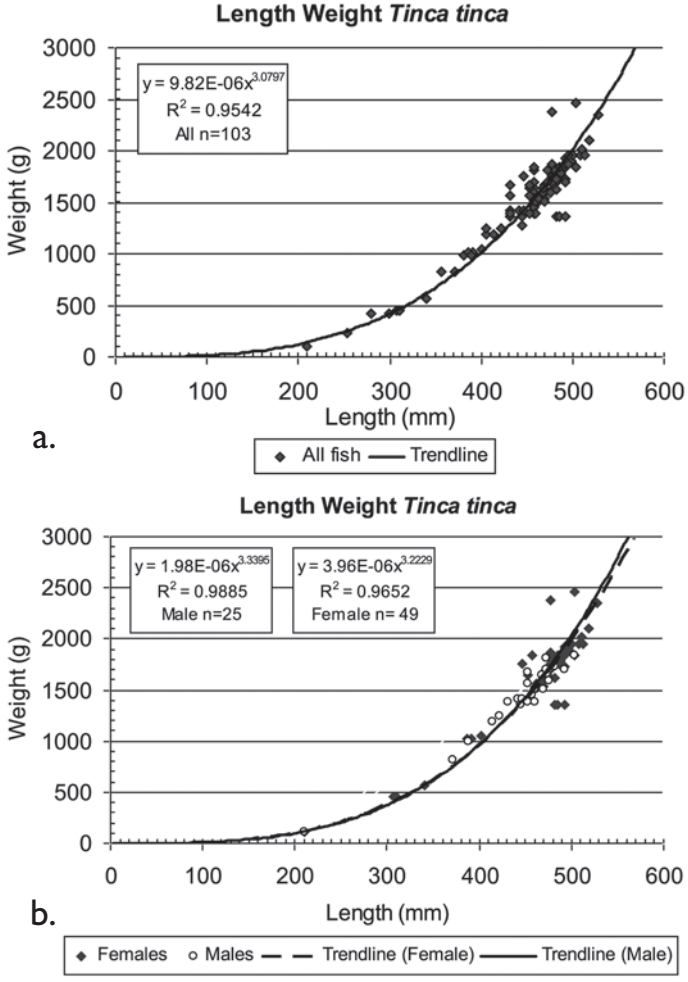


Figure 34. Length - weight relationship for *Tinca tinca* (Tench). a all fish grouped. b, males and females.

General Discussion

Adequate measurements were taken in 21 of the 29 species for comparison of length - weight relationships between the sexes to be made, although in some of these species, numbers were low. In 10 of these 21 species, the length weight curves showed that the females, as they grew, became heavier at a given length, 6 of them markedly so, however only four of these six were significantly different. This suggested that maturation of gonads in females was creating a greater weight increase than in males (Le Cren 1951), which agreed with the visual appearance of these fish. Four species of fish, which included three salmonids, had very similar curves for both sexes. *H. klunzingeri,* the other species with similar male and female curves in this study, would probably have a steeper curve for males if a larger sample had been available, since large males have an enlarged head as do some other Eleotridae such as *M. adspersa*.

In some species at a certain size, males of similar length were heavier than females. *N. australis* and *N. erebi* are an example of this in which the length weight curves crossed at 60 mm and 280 mm respectively, suggesting that males became larger than females at a given length in older fish; the curves for N. *australis* were significantly different. Three species (*G. rostratus*, *M. p. peelii*, and *T. tinca)* indicated that the curve for males was marginally steeper than females. The curves for *M. adspersa* and *P. grandiceps* showed a markedly steeper curve for large males than in females: and this was significantly different in the case of *M. mogurnda*. This occurs because of the large hump which develops on the forehead of the former and the large broad head which develops in the latter.

The results suggest that the growth pattern of a species of fish and resulting shape can determine the exponent of the length - weight relationship. Six of the 29 species had exponents between 2.9 and 3.1 (Table 3) indicating they were very close to 3, the value for isometric growth. Nine had values below 2.9000 and as low as 2.4110 in *M. australasica,* and 14 had values above 3.1000 up to as high as 3.5916 in *G. rostratus*, which indicated growth in these species was allometric.

The method of capturing fish also can influence length - weight relationships. Treasurer (1976) for *S. trutta* and Kipling (1957) for *Salvelinus alpinus* showed that gill netting may select fatter short fish and thinner long fish, but may not catch slimmer immature fish. This would cause a lowering of the exponent in the length - weight relationship and thus a truncation by weight. This could have occurred in *T. tandanus*, *P. fluviatilis*, *C. carpio*, *T. tinca*, *M. ambigua*, *B. bidyanus*, *N. erebi* and to a lesser extent in *M. p. peelii*, *C. auratus* and some of the salmonids some of which were caught in gill nets. Fish caught by drum nets would not be affected in this manner but would be affected by the lack of smaller size classes not captured by drum nets.

Inflexion points indicating changes in shape often occur in length - weight relationship curves at particular stages in the life cycle as suggested by Micha (1971) for grayling and suggested by Davis (1977) for *T. tandanus*. However in the former case Woodland and Jones (1975) suggested

that length - weight relationships changed throughout the life of grayling. The restricted range of sizes of fish in this study constrained by the capture methods, prevented examination of changes of this type.

Mathisen (1969) indicated that in the allometric relationship of weight and length, the exponent reflects some of the yearly variability in feeding condition in the nursery area and the environmental conditions. In most instances in species discussed in this paper, food abundance and environmental conditions, at least in adult fish, play an important part in initiating gonad development (Lake 1967), which is likely to have a similar significant influence on the exponent value to that suggested above. The Hattah results from September and November 1960 (Fig. 5) confirm this, as fish became more rotund as the breeding season progressed.

In *Mastacembulus armatus*, Gupta (1974) found that gonad weight influenced relative condition (length - weight relationship) but visceral weight did not. The development of gonads in females had a greater effect on the curve for relative condition than did the gonads of males. In the present study, development of female gonads had a noticeable effect on the length - weight relationship of *A. agassizii*, *M. ambigua*, *B. bidyanus*, *G. marmoratus*, *G. affinis*, *L. unicolor*, *P. fluviatilis* and *S. fontinalis*.

Le Cren (1951), in his detailed examination of length - weight relationships of *Perca fluviatilis,* considered six discreet groups, larvae, 0 and 1 year old, immature females II, immature females III and older, mature females and mature males. The first three groups are not considered in this paper. He found that the relationship for older immature females was very similar to that of young fish of both sexes. He indicated that a change in the relationship was correlated to maturation rather than age. It would appear that a single length - weight relationship for each species discussed above, within the length ranges sampled, seems adequate as long as ripening gravid females are not considered. The main exceptions to this are *P. grandiceps* and *M. adspersa,* in which the much enlarged head in one and hump on the head in the other alters the relationship in adult males.

In summary, length - weight relationships are influenced by a number of factors including fish shape, maturity, gonadal status and food availability. In inland New South Wales some of these factors change primarily in response to flooding, which may or may not be seasonal. The length weight relationship in *M. ambigua* was shown to vary with location, time of year and flooding, and sex. In the other species in which length - weight relationships of males and females were examined fecund females appeared to have the greatest affect, except in some species in which males developed some enlarged features. These data should provide length weight curves against which new data can be compared, especially for fish caught from receding inland river systems in times of drought, over extraction of water and modification of river flows, which in turn can significantly affect food supplies.

Acknowledgements

I wish to thank the New South Wales State Fisheries for financing and supporting me during this project. I would also like to thank all personnel at the Inland Fisheries Research Station during my time at the research station who helped in the collection of fish, and technical staff who helped in the collection of fish during trout studies when I was located in Sydney. I would also like to thank my partner Dr Gillian Courtice for providing critical comments, editing and encouragement to complete this work.

References

Anderson, J.R., Morison, A.K. and Ray, D.J. 1992. Validation of the use of thin-sectioned otoliths for determining the age and growth of golden perch *Macquaria ambigua* (Perciformes, Percichthyidae), in the lower Murray Darling Basin, Australia. *Australian Journal of Marine and Freshwater Research*. **43**:1103-28.

Arthington, C.H., Conrick, D.L. and Bycroft, B.M. 1992a. *Environmental Study; Barker-Barambah Creek. Volume 2 Scientific Report: Water Quality, Ecology and Water Allocation strategy*. pp.456. Water Resources Commission and Centre for Catchment and In-stream Research, Brisbane.

Arthington, C.H., Conrick, D.L. and Bycroft, B.M. 1992b. The fish of Barker and Baramah Creek**:** Flow and passage requirements. In *Environmental Study; Barker-Barambah Creek. Volume 2 Scientific Report: Water Quality, Ecology and Water Allocation strategy*, Chapter 14. Water Resources Commission and Centre for Catchment and In-stream Research, Brisbane.

Bishop, K.A., Allen, S.A., Pollard, D.A. and Cook, M.G. 2001. Ecological studies on the freshwater fishes of the Alligator Rivers Region, Northern Territory: Autecology. *Supervising Scientist Report* **145**; *Supervising Scientist, Darwin.*

Blühdorn, D.R. and Arthington, A.H. 1994. *The effects of flow regulation in the Barker-Barambah Catchment. Volume 2: Biotic studies and synthesis.* Centre for Catchment and In-stream Research, Griffith University.

Davis, T.L.O. 1977. Age determination and growth of the Freshwater Catfish, *Tandanus tandanus* Mitchell, in the Gwydir River, Australia. *Australian Journal of Marine and Freshwater Research*. **28**:119-37.

Everhart, W.H., Eipper, A.W. and Youngs, W.D. 1976. *Principles of Fishery Science*. Cornell University Press: London.

Gupta, S. 1974. Observations on the reproductive biology of *Mastacembelus armatus* (Lacepède). *Journal of Fish Biology* **6**:13-21.

Harris, J.H. and Gehrke, P.C. 1997. *Fish and Rivers in Stress: The NSW Rivers Survey.* CRC for Freshwater Ecology, Canberra and NSW Fisheries, Cronulla.

Jones, W. 1974. *Age determination and growth studies of four species of fish from the River Murray*. Ph.D. Thesis, University of Adelaide.

Kipling, C. 1957. The effect of gill net selection on the estimation of length-weight relationships. *Journal du Conseil Permanent International pour L'Exploration de la mer*. **23**:51-63.

Kohler. N.E., Casey, G.J. and Turner, P.A. 1996. Length-Length and Length-Weight relationships for 13 shark species from the western North Atlantic. *US Dep. Commer, NOAA. Tech Memo National Marine Fisheries Service NE* **110**: 22p.

Lake, J.S. 1967. Rearing experiments with five species of Australian freshwater fishes. 1. Inducement to spawning. *Australian Journal of Marine and Freshwater Research*. **18**:137-53.

Le Cren, E.D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *Journal of Animal Ecology*. **20**: 201-19.

Llewellyn, L.C. 1966. Age determination of native inland fish of N.S.W. *The Fisherman, Journal of State Fisheries of New South Wales.* March. **2 (4)**: 1-5.

Llewellyn, L.C. 1968. Tagging gives answers to fish growth queries. *The Fisherman, Journal of State Fisheries of New South Wales.* **3(1)**: 1-5.

Llewellyn, L.C. 1971. Breeding studies on the freshwater forage fish of the Murray-Darling river system. *The Fisherman, Journal of State Fisheries New South Wales.* **3(13):** 1-12.

Llewellyn, L.C. 1973. Spawning, development and temperature tolerance of the spangled perch, *Madigania unicolor* (Gunther), from inland waters in Australia. *Australian Journal of Marine and Freshwater Research* **24**: 73-94.

Llewellyn, L.C. 1974. Spawning, development and distribution of the Southern Pigmy Perch *Nannoperca australis australis* Gunther from inland waters in eastern Australia. *Australian Journal of Marine and Freshwater Research* **25**: 121-49.

Llewellyn, L.C. 1978a. Temperature and river height data for fifteen inland rivers of N.S.W. 1963-1967. *New South Wales State Fisheries Report*. p.1-151.

Llewellyn, L.C. 1978b. Temperature and river height data for fifteen inland rivers of N.S.W. 1968-1972. *New South Wales State Fisheries Report*. p.1-137.

Llewellyn, L.C. 1979. Some observations of the spawning and development of the Mitchellian Freshwater Hardyhead *Craterocephalus fluviatilis* McCulloch from inland waters of NSW. *Australian Zoologist* **20(2):** 269-288.

Llewellyn, L.C. 1980. Family Ambassidae. Chanda Perches, etc. Pp. 140-141 in *Freshwater fishes of south eastern Australia,* edited by R.M. McDowall. Reed, Sydney.

Llewellyn, L.C. 1983. The distribution of fish in New South Wales. *Australian Society for Limnology. Special Publication*. **No. 7**. 1 - 72

Llewellyn, L.C. 2005. Breeding biology, and egg and larval development of *Galaxias rostratus* Klunzinger the Murray Jollytail from inland New South Wales. *Australian Zoologist* **33(2)**: 141-165.

Llewellyn, L.C. 2006. Breeding and development of the endangered Purple-spotted Gudgeon *Mogurnda adspersa* population from the Murray Darling. *Australian Zoologist* **33(4):** 480-510.

Llewellyn, L.C. 2007. Spawning and development of the Flat-headed Gudgeon *Philypnodon grandiceps* (Krefft, 1864) (Teleostei:Eleotridae). *Australian Zoologist* **34(1)**: 1-21.

Llewellyn, L.C. 2008 a. Observations on the breeding biology of *Ambassis agassizii* Steindachner, 1867 (Teleostei: Ambassidae) from the Murray Darling Basin in New South Wales. *Australian Zoologist* **34**:476-498.

Llewellyn, L.C. 2008 b. Estimation of Growth of the Golden Perch *Macquaria ambigua* based on a tagging program between 1959 and 1970**.** *Australian Zoologist* **34**:522-527.

Lloyd, L. 1988. Is the Murray Rainbowfish endangered? *Fishes of Sahul*. **4(4), Feb. 1988**: 189-192.

Mathisen, G.A. 1969. Allocation of weight and length measurements for estimation of the average weight of juvenile sockeye salmon. *Journal of the Fisheries Research Board of Canada*. **26(10)**: 2741-6.

Micha, J.C. 1971. Densité de population, age et croissance du barbeau *Barbus barbus* (L.) et de L'ombre *Thymallus thymallus* (L.) dans l'Ourthe . *Ann. Hydrobiologie*. **2**: 47-68.

Pease, B., Walsh, C. and Booth, D. 2004. Variation in sex ratio, size and age within and among catchments, Pp 48-57 In *Description of the biology and assessment of the fishery for adult Long-finned Eels in NSW*. Edited by Bruce Pease. Cronulla Fisheries Centre NSW.

Pusey, B.J., Kennard, M.J. and Arthington, A.H. 2004. *Freshwater fishes of north-eastern Australia.* CSIRO Publishing, Collingwood.

Romanowski, N. 1989. Murray River Rainbowfish: A reply to Lloyd. *Fishes of Sahul*. **5 (4), Sept 1989**: 236-240.

Rowland, S. J. 1998. Age and growth of the Australian freshwater fish Murray Cod, *Maccullochella peelii peelii*. *Proceedings of the Linnaen Society of New South Wales*. **120**: 163-180.

Sanger, A.C. 1990. Aspects of the life history of the Two Spined Blackfish *Gadopsis bispinosus* in King Parrot Creek, Victoria**.** *Proceedings of the Royal Society of Victoria.* **102**: 89-96.

Shearer, K.D. and Mulley, J.C. 1978. The introduction and distribution of the carp *Cyprinus carpio* Linnaeus, in Australia. *Australian Journal of Marine and Freshwater Research*. **29 (51)**: 551-63.

Sloane, R.D. 1984. Distribution abundance, growth and food of freshwater eels (*Anguilla* spp.) in the Douglas River Tasmania. *Australian Journal of Marine and Freshwater Research*. **35**: 325-339.

Treasurer, J.W. 1976. Age, growth and length-weight relationship of brown trout *Salmo trutta* (L.) in the Loch of Strathbeg, Aberdeenshire. *Journal of Fish Biology*. **8**: 241-53.

Wigley, S.E., McBride, H.M. and McHugh, N.J. 2003. Length-Weight relationships for 74 fih species collected during NEFSC research vessel bottom trawl surveys, 1992-99. *NOAA. Technical Memorandum National Marine Fisheries Service –NE*. **171.** p.15.

Wooland, J.V. and Jones, J.W. 1975. Studies on grayling *Thymallus thymallus* L., in Llyn Tegid and the upper River Dee, North Wales. I Age and growth. *Journal of Fish Biology.* **7**: 749-73.

Zar, J.H. 1984. *Biostatistical Analysis*. 2nd Ed. Prentice Hall, Inc. Englewood Cliffs, N.J.